ARCHIVES OF SURGERY

VOLUME 43 OCTOBER 1941 NUMBER 4

COPYRIGHT, 1941, BY THE AMERICAN MEDICAL ASSOCIATION

OSTEOGENIC SARCOMA

AN ANALYSIS OF EIGHTY CASES

CARL E. BADGLEY, M.D.

AND

MARTIN BATTS JR., M.D.

ANN ARBOR, MICH.

Osteogenic sarcoma is the most common type of primary malignant tumor of bone. In the American Registry of Bone Tumors it is represented by the largest number of reported cases, namely, 1,071 out of a total of 2,232 cases. Mercer [1] estimated its incidence as 1 in 75,000 of the general population. At the University Hospital during the period from 1925 to 1938, inclusive, this diagnosis has been established in 80 of 305,760 consecutive hospital registrations, an incidence of 1 to approximately 3,800 registrations. It is believed that osteogenic sarcoma was seen in more cases during this period, but in the additional cases the criteria for diagnosis were not sufficiently well established to warrant inclusion of these cases in this series.

GENERAL CONSIDERATIONS

Osteogenic sarcoma is primarily a disease of the young. In 40 of our cases, or 50 per cent, it occurred in the second decade of life. The average age of the patients at the time of admission was 29 years; the youngest was 8 years of age; the oldest was 72. Figure 1 shows the distribution of the tumors in our series according to decades of life.

The sex incidence was 51 men and 39 women, or 64 and 36 per cent, respectively.

The family history was positive for one or another type of tumor in 11 cases, or 13 per cent. There was no family history of tumor in 51 cases, and in the remainder this fact was not ascertained.

Twenty-nine patients, or 36 per cent, gave a history of trauma preceding the onset of symptoms. The trauma was usually not severe

From the Department of Surgery, Section of Orthopedics, University of Michigan Medical School.

1. Mercer, W.: Orthopaedic Surgery, ed. 2, Baltimore, William Wood & Company, 1936.

and on the average antedated the symptoms by a few weeks to a few months. The high proportion of patients with a history of trauma has been noted repeatedly in the literature and suggests that trauma may play an etiologic role in the development of osteogenic sarcoma.

The average duration of symptoms from the onset until the time of admission was thirteen months. The shortest duration was in a patient who had noted a painless swelling over the maxilla two weeks previous to admission. The longest duration of symptoms was ten years; a diagnosis of an osteochondroma with malignant change was made in this

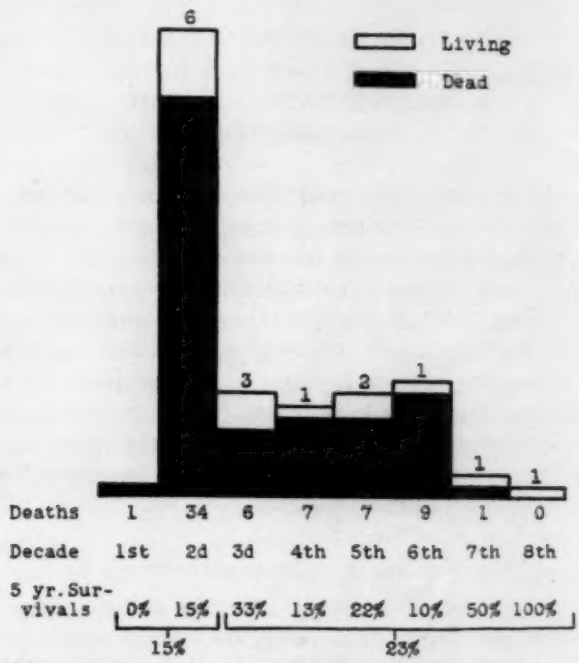


Fig. 1.—Distribution of the tumors diagnosed as osteogenic sarcoma according to decades of life, with the number of patients in each age group who have died, the number who are living, and the percentage of five year survivals.

patient, and it is probable that the malignant process had not been present during the entire period of symptoms.

The outstanding symptoms were pain and swelling. Pain was present in all but 1 patient. The pain almost invariably preceded the appearance of the tumefaction. This is of some significance, since in many benign tumors of bone, pain, if it is present, is noted after the appearance of the swelling. The pain in most instances was relatively mild at the onset, rapidly becoming more constant and severe. It was often worse at night. When well developed, the pain was not relieved by rest. It was followed after a variable period by swelling of the involved area. Motion of the adjacent joint then became affected, and

a limp developed in the lower extremity. Many patients were unable to walk without external support at the time of admission. Constitutional manifestations, such as fever, loss of weight, anorexia and ready fatigue, were noted in a relatively small proportion of the cases. Almost without exception the patients were in good general health at the time of the onset of symptoms.

A palpable tumor was present in 73 cases, or 91 per cent. The tumor was hard in consistency and usually moderately tender. Increased heat

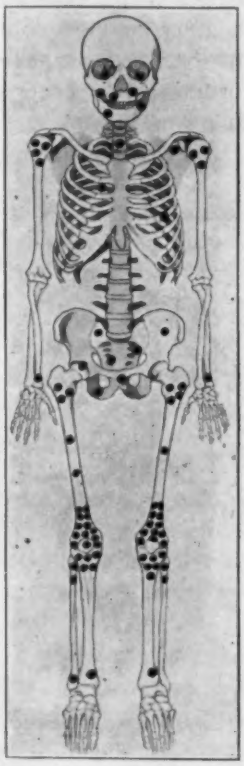


Fig. 2.—Distribution of lesions, showing predilection for the ends of long bones.

and dilatation of the superficial vessels over the tumor were frequently noted. In the extremities there was limitation of motion of the adjacent joints. Ulceration of the overlying skin was noted in 5 cases, although this is generally considered an unusual finding. Regional lymphadenopathy was noted in only 2 cases. The patient's general condition was usually good on admission though a low grade fever was an occasional finding.

In this series the lesions showed a marked predilection for the ends of the long bones. In 40 cases, or 50 per cent, they were located

in the vicinity of the knee joint as follows: lower end of the femur in 25 cases; upper end of the tibia in 11 cases; upper end of the fibula in 4 cases. Figure 2 shows the distribution of the lesions.

In this series the diagnosis was established on the basis of the combined clinical, roentgenologic and histologic studies in 62 cases. In the remaining 18 cases, histologic examination was not carried out, but there were typical clinical and roentgenologic findings, with the appearance of metastases, followed by death within a relatively short time.

The classification of tumors of this type into subgroups is beset with many difficulties, and unanimity among various examiners of the same lesions is unusual. However, an attempt was made to classify the tumors in this series according to the criteria outlined by Geschickter and Copeland [2] into the following groups: (1) primary myxochondrosarcoma, (2) secondary chondrosarcoma, (3) osteoblastic (sclerosing) osteogenic sarcoma, (4) chondroblastic sarcoma and (5) osteolytic sarcoma. Of the 62 tumors from which material was available for histologic study, it was believed that 48 allowed fairly accurate classification into these subgroups. Table 1 shows the classification of these 48 lesions.

TABLE 1.—*Correlation Between the Types of Osteogenic Sarcoma and the Periods of Survival in 48 Cases*

Type of Lesion	Cases	Average Period of Survival, Mo.	Five Year Survivals	Percentage of 5 Yr. Survivals
Primary myxochondrosarcoma	11	13	1	9
Secondary chondrosarcoma	14	33	4	29
Sclerosing osteogenic sarcoma	14	48	6	43
Chondroblastic sarcoma	2	16	0	0
Osteolytic osteogenic sarcoma	7	10	0	0

The treatment of choice in this series was radical amputation. This was usually carried out without preoperative application of roentgen radiation. When used postoperatively, roentgen therapy was employed as a palliative measure, generally for pulmonary metastases. Local excision was carried out for lesions in locations not amenable to amputation, usually with postoperative roentgen therapy. In a few cases roentgen therapy only was used, in each instance as a palliative measure for far advanced lesions. Three patients received symptomatic treatment only. Table 2 shows the types of treatment employed and the number of cases in each group.

END RESULTS

Follow-up studies were carried out in every case in this series. Sixty-three patients died, a mortality rate of 79 per cent. Of the 17

2. Geschickter, C. F., and Copeland, M. D.: Tumors of Bone, New York, American Journal of Cancer, 1936.

patients who survived, 1 patient had metastases, and the others were well at the time of writing. The shortest period of survival was that of a patient who died within twenty-four hours after resection of a lesion involving the ribs. The longest period of survival was that of a patient who was still living and well fourteen years and seven months after a midthigh amputation. The average period of survival in cases with a fatal termination was thirty-one months. The average period of survival of those who were living at the time of the last follow-up study was eighty-four months. The average period of survival for the entire eighty cases at the time of writing was forty-one months. There were 15 5-year survivals, an incidence of 19 per cent. There were 4 ten year survivals. The discrepancy between the numbers of five and ten year survivals is explained by the fact that only 4 patients have had a ten year follow-up study. That even a ten year survival

TABLE 2.—*Correlation Between the Types of Treatment and the Periods of Survival in 80 Cases*

Type of Treatment	Cases	Average Period of Survival, Mo.	Five Year Survivals	Percentage of 5 Yr. Survivals
Amputation	22	35	6	27
Amputation and roentgen therapy	21	43	7	33
Local excision	3	32	1	33
Excision and roentgen therapy only	10	21	1	10
Roentgen therapy only	20	7	0	0
Symptomatic	3	25	0	0

does not constitute a cure is shown by the fact that 1 patient died of pulmonary metastases which developed thirteen years after a midthigh amputation.

PROGNOSIS

Many factors influence the prognosis of a patient with osteogenic sarcoma. To evaluate these factors an attempt was made to correlate the period of survival with the age of the patient, the duration of symptoms previous to treatment, the status of the neoplasm on admission, the performance of biopsy before or at the time of treatment, the location of the lesion, the type of the lesion and, finally, the type of treatment, including the site of amputation.

The average period of survival following treatment for the entire series was twenty-nine months. Forty-one patients were below 20 years of age; in this group the average period of survival was twenty-one months, and there were 6 five year survivals, or 15 per cent. Among the 39 patients aged 20 years and above, the average period of survival was thirty-five months, and there were 9 five-year survivals, or 23 per cent. Thus, in the older group the prognosis was considerably better both with regard to the average period of survival

and the percentage of five-year survivals. The 2 oldest patients, aged 69 and 72 years, were living and well, eighty-three and sixty-six months, respectively, after treatment.

Ferguson,[3] in a recent review of 400 cases of osteogenic sarcoma, compared the prognosis for patients who received treatment less than six months after the onset of symptoms with the prognosis for patients who received treatment more than six months after the onset of symptoms. It was found that the group with the greater duration of symptoms had the better prognosis. In this series 46 patients had symptoms less than six months; among these the average period of survival was twenty months, and there were 8 five year survivals, or 17 per cent. Among the 34 patients having symptoms more than six months the average period of survival was thirty-one months, and there were 7 five year survivals, or 23 per cent. These figures are in agreement with those of Ferguson. It is believed that the explanation of this apparent indication for the delay of treatment lies in the fact that the more malignant type of lesion drives the patient to seek aid earlier in the course of his disease.

The average period of survival of those patients who had metastases on admission was only four months as compared with an average of twenty-nine months for the entire series.

There were 19 patients who underwent biopsy previous to surgical treatment. The biopsy was usually carried out a few days previous to the subsequent procedure. The average period of survival in this group was twenty-eight months, compared with an average of thirty-five months for the group which did not have previous biopsy. The danger of a preliminary biopsy has never been conclusively demonstrated, and the evidence herewith produced is regarded as merely suggestive.

The correlation between the sites of the lesions and the periods of survival is shown in table 3. As might have been expected, the group with the more central lesions had a shorter average period of survival and fewer five year survivals. This fact is strikingly illustrated by comparing the periods of survival of two groups of patients, those with lesions above and those with lesions below the knee. The average period of survival and the number of five year survivals were more than twice as favorable in the group with lesions below the knee.

It is obvious that the most important factor in determining the prognosis in any patient is the type of lesion. If all patients with osteogenic sarcoma had approximately the same prognosis, the classification of the lesions into various subgroups would have little more

3. Ferguson, A. B.: Treatment of Osteogenic Sarcoma, J. Bone & Joint Surg. **22**:92-96 (Jan.) 1940.

than academic value. However, an analysis of 48 cases showed considerable variation in prognosis between the various types, as shown in table 1. Progressing from the least favorable to the most favorable prognosis, the order was found to be osteolytic osteogenic sarcoma, chondroblastic sarcoma, primary myxochondrosarcoma, secondary chondrosarcoma and sclerosing osteogenic sarcoma. These results agree in general with those recorded by Geschickter and Copeland [2] and furnish another demonstration of the fact that the more highly differentiated the lesion the better the prognosis.

Table 2 shows the results of the various types of treatment employed. All but 2 of the patients with five year survivals underwent amputation, either with or without roentgen therapy. For the 43 patients treated by amputation, the average period of survival was forty-two months, and there were 13 five year survivals, an incidence of 30 per cent. This was in striking contrast to the results in 37 patients

TABLE 3.—*Correlation Between the Sites of Osteogenic Sarcoma and the Periods of Survival in 80 Cases*

Site of Lesion	Cases	Average Period of Survival, Mo.	Five Year Survivals	Percentage of 5 Yr. Survivals
Trunk	11	21	1	9
Face and skull	7	25	1	14
Upper extremity	9	27	2	22
Lower extremity	53	30	11	21
(a) Above knee	35	21	5	14
(b) Below knee	18	49	6	33

not treated by amputation, for whom the average period of survival was fifteen months and the number of five year survivals only 2, an incidence of 5 per cent. It would seem that amputation still offers the best chance of cure of osteogenic sarcoma. The results in the patients treated by amputation plus roentgen therapy were a little more favorable than those in patients treated by amputation alone. However, roentgen therapy was almost always used for palliation of pulmonary metastases, and no conclusions regarding the curative value of roentgen therapy in cases of osteogenic sarcoma are warranted from a study of this series.

It has been stated that amputation should be carried out at the next higher joint, at least, and never through the bone involved. In this connection it is interesting to compare the results of amputation through a thigh for a lesion below the knee with the results of amputation through a thigh or disarticulation of a hip for a lesion above the knee. In only 1 case was it considered justifiable to amputate below the knee; the patient had a lesion of the distal part of the tibia and is living and well at the time of writing, seventy months after

treatment. Thirteen patients underwent a thigh amputation for a lesion below the knee; in this group the five year survivals numbered 5, an incidence of 38 per cent. Sixteen patients with a lesion of the femur were treated by a midthigh or high thigh amputation; in this group five year survivals numbered 5, an incidence of 31 per cent. Thus, including the patient who underwent amputation through the tibia, there were 17 patients in whom the involved bone was transected, with 6 five year survivals, an incidence of 35 per cent. Disarticulation of a hip was carried out in 8 patients with a lesion of the femur, and in this group there were no five year survivals. Thus, there were 21 patients in whom amputation was carried out proximal to the involved bone, with five year survival in 5, an incidence of 28 per cent. Table 4 shows the correlations.

It is evident, as Coley and Pool [4] have pointed out, that the dictum that amputation should be carried out at the next higher joint,

TABLE 4.—*Correlation Between the Sites of the Lesions, the Levels of Amputation and the Periods of Survival in 38 Cases*

Site of Lesion	Site of Amputation	Cases	Average Period of Survival (Mo.)	Five Year Survivals	Percentage of 5 Yr. Survivals
Tibia or fibula	Upper part of tibia	1	70	1	100
	Lower part or middle of thigh	13	58	5	38
Femur	Middle or upper part of thigh	16	37	5	31
	Disarticulation of hip	8	11	0	0

at least, and never through the involved bone is without support. Death, if it occurs, is almost always due to distant pulmonary metastases, and, as has been previously noted, the more centrally located the lesion the poorer the prognosis. This is a sufficient explanation for the poor results of disarticulation of a hip. It is believed that for any lesion in an extremity the lowest level of amputation compatible with complete eradication and the requirements for a suitable prosthesis should be considered satisfactory.

In this series there were 4 patients who had recurrence in the stump. In 2 patients there was recurrence after disarticulation of a hip. For these patients hemipelvectomy was not considered justifiable, 1 had involvement of the neck of a femur, and the other had involvement of the subtrochanteric area of a femur. There was 1 patient who had a recurrence after amputation in the upper part of the thigh for a lesion extending 8 inches (20 cm.) above the knee joint. Perhaps disarticu-

4. Coley, B. L., and Pool, J. L.: Factors Influencing Prognosis in Osteogenic Sarcoma, Ann. Surg. **112**:1114-1128 (Dec.) 1940.

lation of the hip was indicated in this patient, but in our series there were no five year survivals after such treatment. There was 1 patient who had a recurrence in the stump following amputation in the lower part of the thigh for a sarcoma of the upper part of the tibia; undoubtedly a higher level of amputation was indicated, but in this patient the usual rule was violated, that osteogenic sarcoma does not "jump a joint."

The progressive encouragement to which a patient is entitled as he outlives his lesion after treatment suggested the computation of the odds on a cure at the end of each successive year of survival. The results are shown in table 5. Seventy-six patients have either died or survived treatment more than five years without evidence of recurrence or metastases. Since 2 of the 15 patients with five year survivals died as a result of the extension of their malignant lesions, only 13

TABLE 5.—*Odds on Survival at Different Periods of Survival* *

Interval of Time	Patients Dead	Patients Living	Percentage of Cures	Odds on Cure
Admission	0	76	17	1 to 5
End of first year	43	33	39	2 to 3
End of second year	9	24	54	5 to 4
End of third year	7	17	76	3 to 1
End of fourth year	2	15	87	7 to 1
End of fifth year	0	15	87	7 to 1
After fifteen years	2	13	100	100%

* The calculations are based on 76 cases with 13 cures; 2 patients died after survival period of five years.

patients are regarded as having been cured. At the time of admission the patient's chance of a cure was 1 to 5, whereas at the end of the fifth year it was 7 to 1. Judging from the patient who died of his lesion more than thirteen years after treatment, one cannot absolutely rule out the likelihood of recurrence after the lapse of at least that many years.

SUMMARY AND CONCLUSIONS

Osteogenic sarcoma is the most common type of primary malignant tumor of bone. It is primarily a disease of the young, one half of the patients being in the second decade of life. It is more common in men than in women. Only a small proportion of the patients have a family history of one or another type of malignant lesion. Trauma is associated with the development of osteogenic sarcoma in about one third of the patients.

The average duration of symptoms from the onset until diagnosis is thirteen months. The outstanding symptom is pain followed by swelling. A palpable tumor is present in 90 per cent of cases. The lesions show a marked predilection for the ends of the long bones; about 50 per cent of the lesions appear in the vicinity of the knee

joint. The diagnosis is based on a combination of characteristic clinical findings and roentgenographic and histologic observations. The treatment of choice is primary amputation. If the lesion is not amenable to amputation, local excision should be carried out in conjunction with roentgen therapy.

In this series there was a mortality rate of 79 per cent at the time of writing. The average period of survival was forty-one months. Among 80 patients there were 15 five year survivals, an incidence of 19 per cent. There were 4 ten year survivals, an incidence of 5 per cent. The longest period of survival was that of a patient who was living and well fourteen years and seven months after treatment. One patient died of pulmonary metastases which developed thirteen years after a midthigh amputation.

The prognosis is more favorable for patients over 20 years of age. The prognosis is less favorable for patients with a relatively short duration of symptoms when the diagnosis is established; for the more lethal lesions drive the patients to seek earlier treatment. The danger of the dissemination of tumor cells by a preliminary biopsy has not been conclusively demonstrated. In the extremities, the more central the lesion the poorer the prognosis. The prognosis varies directly as the degree of differentiation of the lesion. If the lesion occurs in an extremity, the period of survival is most favorably influenced by amputation. Transection of the involved bone is not contraindicated, provided it is above the upper limits of the lesion. As the patient outlives his lesion after curative therapy, the prognosis becomes progressively more favorable.

REPRODUCTION OF ULCERATIVE COLITIS IN DOGS

J. K. POPPE, M.D.
Assistant in Surgical Bacteriology and Pathology, Yale University School of Medicine
NEW HAVEN, CONN.

The attempt to reproduce ulcerative colitis in dogs was prompted by the work of Reichert and Mathes,[1] who experimentally produced lymphedema of the intestinal tract. Similarity was noted between experimental lymphedema and clinical regional enteritis or terminal ileitis. The extension of ulcerative colitis into the small intestine as ileitis has been recognized in certain cases.

This experimental work followed a procedure for producing obstruction of the mesenteric lymphatics by the injection of a sclerosing solution which has been described elsewhere.[1] An attempt was made to inject the solution into the lymphatics draining the terminal portion of the ileum and the colon in order to produce the disease process primarily in the colon rather than in the ileum. Preliminary injections of several types of bacteria were made in an effort to determine which is most pathogenic for the colon and produces the most marked disease process in that organ.

METHOD

The sclerosing solution used was the one which Reichert and Mathes found most satisfactory, namely, a 26 per cent bismuth oxychloride aqueous solution to which a small amount of rose aniline dye (in the form of indelible lead) was added. The bismuth oxychloride solution was prepared according to Poth's[2] modification of Hill's bismuth oxychloride mass (1 part of bismuth to 2 parts of oxychloride powder). This was injected into one or more lymphatics in small amounts, close to the intestine. A fat meal given three to four hours before operation was the most satisfactory means of dilating the lymphatics for injection. The sclerosing solution could not be injected directly into the lymphatics in the mesocolon proper owing to the lack of dilatation of these lacteals by the ingested fat; dilation decreased progressively toward the distal end of the intestinal tract. Therefore the injection was made as close to the colon as possible in the mesentery of the ileum. The injections were made through a short-beveled

Prof. Samuel C. Harvey and Asst. Prof. Gustaf E. Lindskog assisted in carrying out the experiments.

1. Reichert, F. L., and Mathes, M. E.: Experimental Lymphedema of the Intestinal Tract and Its Relation to Regional Cicatrizing Enteritis, Ann. Surg. **104**:601 (Oct.) 1936.

2. Poth, E. J.: A Modification of Hill's Radiopaque Mass for the Injection of Lumina, J. Lab. & Clin. Med. **19**:1241 (Aug.) 1934.

gage 27 hypodermic needle; a magnifying dissecting loupe was used to accentuate the lumens of the tiny vessels, as described by Homans, Drinker and Fields.[3] A sufficiently large amount of solution was injected to fill partially the nodes at the base of the mesentery, thereby obstructing the lymphatic drainage from the colon as well as from the terminal portion of the ileum. A twenty-four hour broth culture of living organisms was injected intravenously into some of the animals three hours before operation. Saline washings of organisms from a blood agar slant culture were used in some experiments without any noticeable difference in reaction. In 1 case the living organisms were mixed with the sclerosing solution and injected directly into the lymphatics at operation.

Fig. 1.—Roentgenogram showing radiopaque material in the mesenteric lymphatic vessels and a lymph node.

Cultures of Bacillus coli, Streptococcus viridans, Staphylococcus aureus and Streptococcus haemolyticus were used individually in 1 or more instances. All the dogs except 1 were maintained until spontaneous death in an effort to observe results over a long postoperative period. Infusions of saline and dextrose solution were used in a number of the animals to prolong their postoperative course.

The postoperative symptoms in all of these dogs were about the same for the first several weeks. All of them lost any desire for the usual dog chow and would take only small amounts of water and ground meat. On about the second

3. Drinker, C. K.; Fields, M. E., and Homans, J.: The Experimental Production of Edema and Elephantiasis as a Result of Lymphatic Obstruction, Am. J. Physiol. **108**:509 (June) 1934.

postoperative day profuse bloody diarrhea, often amounting to several pints of almost gross blood, developed in all the dogs. During this period they showed a rapid loss of strength and activity. Some of them vomited bloody material for several days preceding death. The actual cause of death in a number of these animals was shock from the loss of blood by hemorrhage into the intestine.

The 3 animals which lived longer than two weeks gradually regained some of their appetite and activity but lost weight and strength until they died. Moderate diarrhea persisted in these animals, although the bleeding stopped. Dog 1 lost one third of its original body weight in five months. Dogs 2 and 3 each lost one fifth of their original weight in two and four months, respectively. Large ulcers developed on the hindlegs of dog 3; these progressed in size until the dog died.

Fig. 2.—Section of colon taken from dog 2 showing deep ulceration of the mucosa with a cellular infiltration extending down into the deep muscular layers. This dog received no bacterial injection and lived two months after operation.

Autopsy was performed as soon as possible in every case, with immediate fixation of the intestines in solution of formaldehyde U. S. P. to prevent autolysis.

RESULTS

The common pathologic finding in all the intestines was marked enlargement of the lymph nodes draining the injected portions of the intestines. This enlargement of the lymph nodes appeared generalized in a number of cases, including all the nodes at the base of the mesentery. These nodes were firm and showed large amounts of foreign material, some of which was present in large phagocytes. Extensive calcium

deposits and fibrosis were noted in the mesenteric nodes of dog 1, which lived for five months after operation. The mesentery of the injected portions of bowel was much thickened and shortened with numerous adhesions in dogs with the more chronic involvement. The walls of the

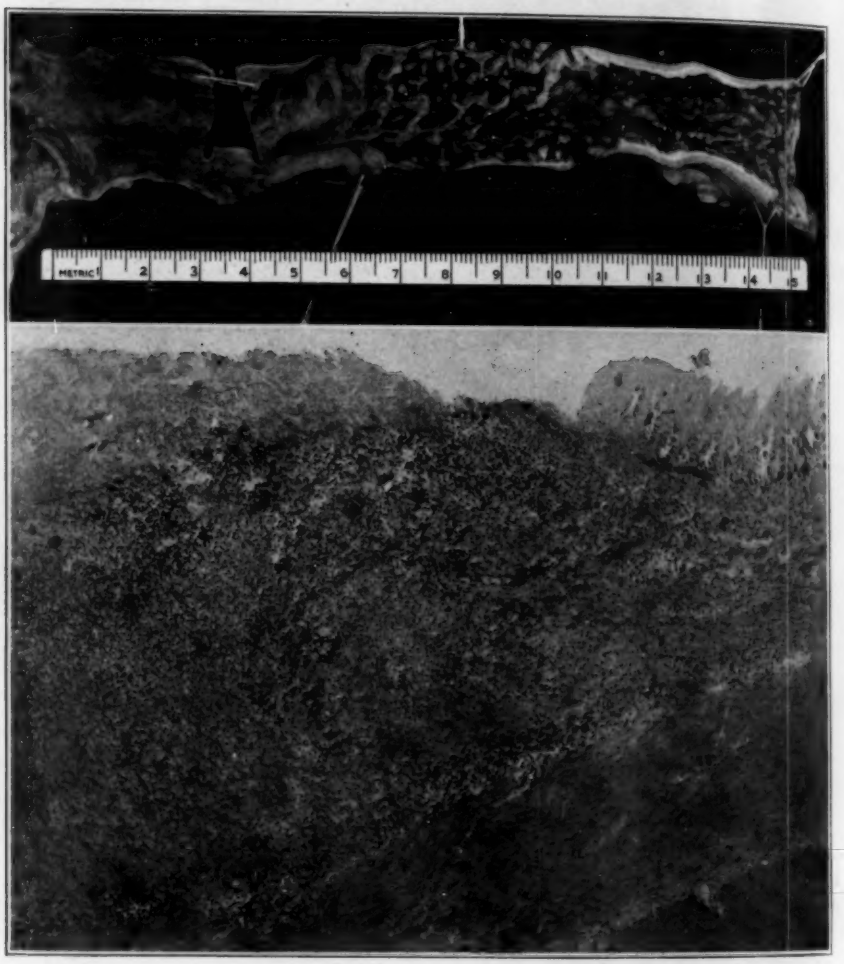


Fig. 3.—The gross and microscopic pictures of an extensive area of ulceration of the colon, with complete destruction of the mucosal layer and a heavy cellular infiltration of the wall in this area.

injected intestinal segments in the animals which lived longer than two weeks were all somewhat thickened, and the lumens were narrowed. The walls of the involved ileum in some of the animals with acute, short term involvement appeared thin, friable and about ready to rupture. Actual acute and chronic ulceration of the mucosal layer of the colon was noted in 5 animals (2, 8, 13, 14 and 15). Only 1 of these animals

(2) had received any bacterial injection. No ulceration was noted in the ileum of any animal, although the wall of the ileum was definitely involved in the disease process in all of them.

Microscopic examination of the mesenteric lymph nodes and vessels showed marked variation depending on the stage of the disease process when death occurred. In animals with the acute form of the disease the mesenteric lymphatic vessels were crowded with large accumulations of polymorphonuclear and mononuclear cells and phagocytes containing foreign pigment. The long term dogs showed obliteration of the lumens

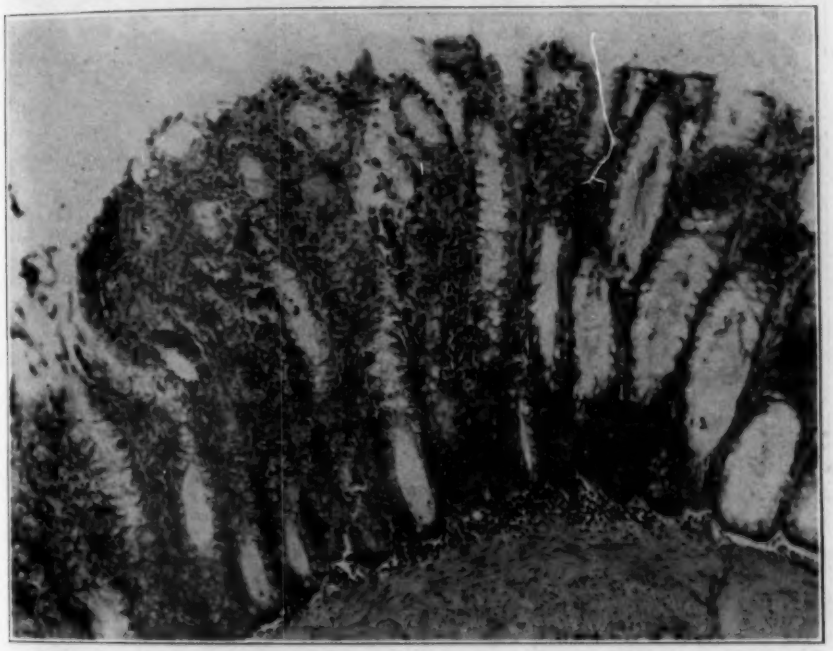


Fig. 4.—Section taken from the edge of a beginning ulceration of the mucosa of the colon in dog 14 showing cellular infiltration in the mucosal and submucosal layers and irregularity of the mucosal patterns. This animal was killed on the tenth day after operation, at an acute stage of the experimental disease.

of the lymphatic vessels by organizing thrombi and fibrosis. The same fibrotic reaction around the foreign pigment often replaced a large part of the lymphoid tissue in the mesenteric lymph nodes. No thrombosis, either gross or microscopic, was noted in any of the blood vessels in the mesentery proper.

The histologic examination of the intestine showed a moderate to marked cellular reaction in the submucosal layer of the injected segment, gradually fading out in the adjoining segments. This cellular reaction varied from a single layer of cells to a heavy infiltration of the submucosal region with marked hyperplasia of the lymph follicles. This cellular

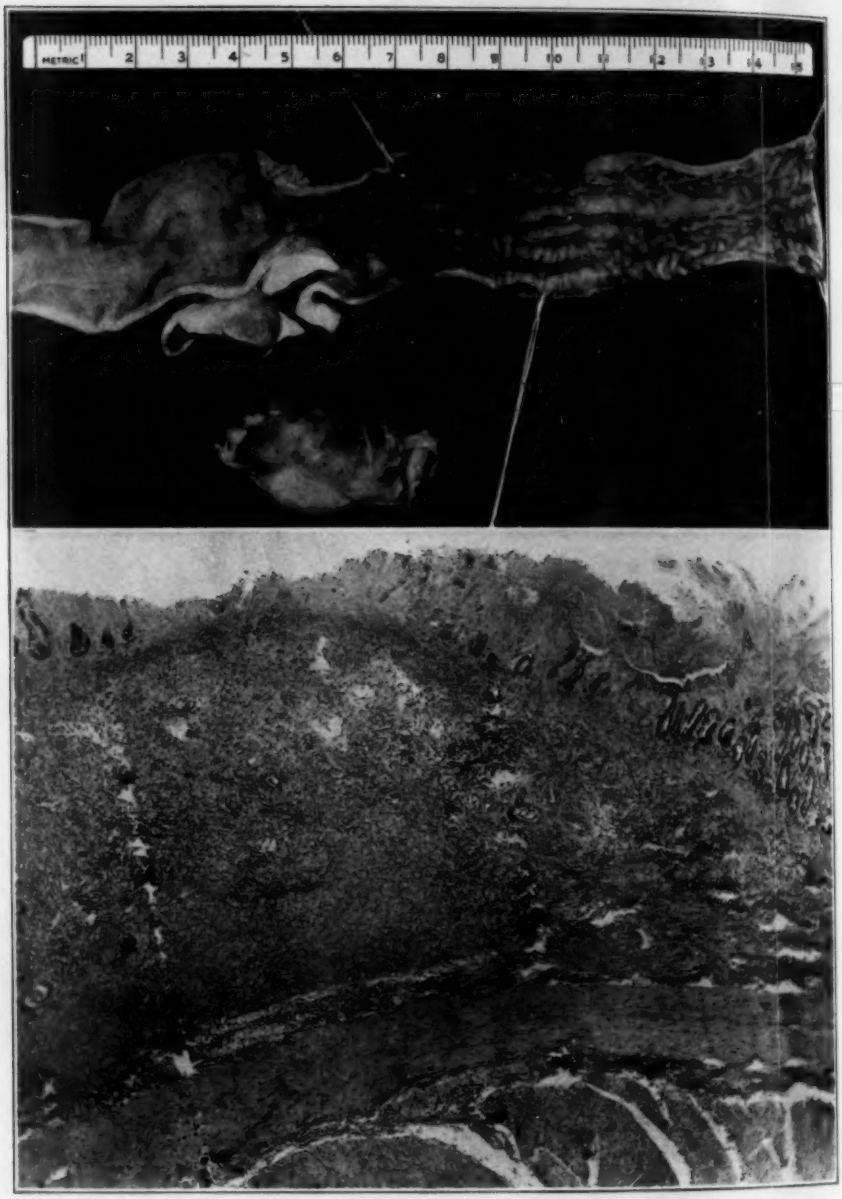


Fig. 5.—The gross and microscopic pictures of an area of early ulceration of the mucosa of the colon of dog 15 showing marked thickening of the submucosal layer associated with extensive cellular infiltration.

proliferation was most marked in the animals with the acute form of the disease, especially around the actual ulcerations of the mucosa of the colon. In these areas the intestinal wall was increased to three or more times normal thickness as measured against uninvolved portions of the same bowel. Part of this cellular response in the chronic form was replaced by increased fibrous tissue in the submucosal region, although this cellular proliferation was present to a certain degree in both the small and the large bowel in both the acute and the chronic involvements.

The ulcerations found in the mucosa of the colon were frequently extensive. They were almost always found in the most proximal portions of the large bowel, which was the area receiving the major portion of the injections. The ulcerations varied greatly in depth, ranging from destruction of the mucosal layer alone with preservation of the muscularis mucosa to deep ulceration extending down into the deep muscle layers of the wall. The bases of these ulcers were lined by both polymorphonuclear and mononuclear cells and showed thrombi in the smaller-sized vessels. An apparently healing ulceration was seen in the mucosa of the colon of one of the long term dogs (1). This ulceration was distinguished by a disruption of the mucosal pattern over certain areas of thickened wall, accompanied by the presence of glandular structures in the submucosal region.

The pathologic reaction in the small intestine was different in that marked edema and loss of the mucosa covering the tips of the folds occurred rather than ulceration as in the colon. The underlying submucosal cellular reaction appeared to extend right into the tips of the villi in the acute forms. This enteritis was the probable cause of the severe hemorrhages into the bowel during the acute stages.

COMMENT

The results in 6 of the 21 dogs given injections were discarded owing to technical difficulties which caused the death of the animals during the first few postoperative hours, such as too large injections of sclerosing solution or pulmonary congestion after vomiting and aspiration of the fatty meal. Consideration of the remaining 15 animals reveals the following types of preparation: 11 animals had intravenous injections of bacteria before operation (4 of these were given Str. viridans [5, 8, 10 and 12], 3 were given Staph. aureus [4, 6 and 9], 2 were given Str. haemolyticus [7 and 11], and 1 was given B. coli [1]); 1 dog (3) was given B. coli mixed with the sclerosing solution, injected directly into the mesenteric lymphatics at operation; 4 animals (2, 13, 14 and 15) received no bacterial injections.

The postoperative survival period varied for the 15 dogs; 3 (1, 2 and 3) lived longer than two weeks, and only an additional 2 (7 and 14) lived longer than eight days.

All these 15 animals had a pathologic response in the region of the injected mesentery, ranging from acute enteritis to ulceration and fibrosis of the intestinal wall. Only 1 animal (2) that received a bacterial injection presented ulceration of the mucosa of the colon. All of the animals which did not receive intravenous bacterial injections showed actual ulceration of the mucosa. The apparent reason for this was that a more localized and chronic type of inflammation was induced in the intestinal walls of these animals by the bacteria which were naturally present, in contrast to the overwhelming enteritis produced by the injections of organisms into the blood stream under conditions of obstructed lymphatic drainage. Previous experiments by Taffel [4] showed that the injection of organisms into the blood stream of a dog has almost no effect in the absence of lymphatic obstruction.

Reproduction of Ulcerative Colitis in Dogs

Animal	Weight, Kg.	Amount of Sclerosing Solution, Cc.	Infecting Agent		Time After Operation to Death	Site of Disease
			Type	Amount, Cc.		
1	17	2	Bacillus coli	2.5	5 mo.	Ileum and colon
2	24	10	.....	...	2 mo.	Jejunum, ileum and colon
3	10	5	B. coli	1	4 mo.	Ileum and colon
4	15	5	Staph. aureus	0.5	12 days	Ileum and jejunum
5	15	5	Str. viridans	0.5	4 days	Colon and ileum
6	12	3	Staph. aureus	0.5	2 days	Colon and ileum
7	20	3	Str. haemolyticus	0.5	8 days	Colon and ileum
8	15	3	Str. viridans	0.5	6 days	Colon and ileum
9	7.5	3	Staph. aureus	0.5	6 days	Colon and ileum
10	7.2	2.5	Str. viridans	0.5	5 days	Colon and ileum
11	7.1	2.5	Str. haemolyticus	0.5	4 days	Colon and ileum
12	15	2.5	Str. viridans	0.5	6 days	Colon and ileum
13	6.5	2.5	.....	...	4 days	Colon and ileum
14	15	2	.....	...	10 days	Colon and ileum
15	5	2.5	.....	...	6 days	Colon and ileum

CONCLUSIONS

Acute and chronic enteritis, including ulceration of the mucosa of the colon, can be produced in dogs by obstructing the lymphatic drainage of the ileocecal segment of intestine. The presence of mesenteric lymphatic obstruction is sufficient to produce this ulceration of the rectal mucosa without the injection of any bacteria.

None of the organisms tested by injection appeared to have any specificity in producing ulceration of the mucosa of the colon. The more pathogenic organisms appeared to produce acute generalized enteritis rather than the chronic ulcerative form.

The mucosa of the colon has a definite tendency to ulcerate following lymphatic obstruction produced by this method, in contrast with that of the small bowel, which reacts with more acute catarrhal enteritis.

4. Taffel, M.: Experimental Production of Brain Abscesses, unpublished data.

SUBDURAL HYDROMA

DOMINGOS GUILHERME DA COSTA, M.D.
Fellow in Neurosurgery, the Mayo Clinic
AND
ALFRED W. ADSON, M.D.
ROCHESTER, MINN.

One of the complications which follow injury of the head is the accumulation of cerebrospinal fluid between the dura and the arachnoid. This is called meningitis serosa traumatica, traumatic arachnoiditis, post-traumatic subdural cyst, circumscribed hydrocephalus or subdural hydroma. Since the lesion frequently is not recognized, and the symptoms are attributed to cerebral injury, we believe a review based on our series of 19 cases is justified.

As early as 1894, Charles H. Mayo [1] reported a typical case of subdural hydroma but classified the lesion as a cerebral cyst. A boy of 12 who had sustained an injury of the head was brought to him because of severe headache, aphasia and right hemiplegia. Trephining on the left side, Mayo found in the subdural space a circumscribed collection of fluid resembling cerebrospinal fluid. The cyst was evacuated and drained; although the brain did not reexpand immediately after the operation, the late results were excellent, and complete recovery ensued.

Although Payr [2] described subdural hydroma, Naffziger [3] was the first to give a satisfactory clinical and pathologic description of the lesion. He pointed out that the accumulation of fluid did not result from cerebral edema, as had been thought, but was the result, instead, of cerebrospinal fluid pouring into the subdural space through a tear in the arachnoid. Cerebrospinal fluid is contained within the arachnoid and normally does not enter the space between the arachnoid and the dura (fig. 1*a*). As a rule, none or only small quantities of serous transudate are found between these membranes at the time of craniotomy. However,

---

From the Section on Neurologic Surgery, the Mayo Clinic.

1. Mayo, C. H.: A Brain Cyst: The Result of Injury Causing Aphasia, Hemiplegia, etc.; Evacuation; Complete Recovery, New York M. J. **59**:434 (April 7) 1894.

2. Cited by Cohen.[12]

3. Naffziger, H. C.: Subdural Fluid Accumulations Following Head Injury, J. A. M. A. **82**:1751-1752 (May 31) 1924.

Penfield [4] observed yellow coagulated masses in the subdural space in serial sections of frozen heads of normal dogs.

Since subdural hydroma develops subsequent to an injury of the head, it is reasonable to assume that a tear has occurred in the arachnoid which allows escape of the cerebrospinal fluid into the space between the arachnoid and the dura (fig. 1*b*). The arachnoidal tear usually occurs in the region of the sylvian fissure (fig. 2) or in the region of the optic

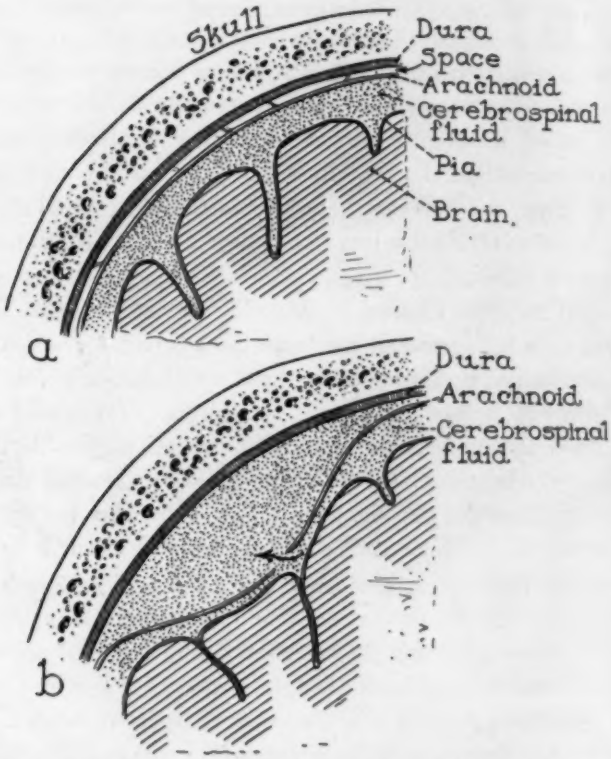


Fig. 1.—(*a*) Anatomic relation of subarachnoid spaces to surrounding structures; (*b*) hydroma, collection of cerebrospinal fluid between arachnoid and dura.

chiasm. Inasmuch as the resistance to flow of cerebrospinal fluid is less through a rent in the arachnoid than over the brain, the fluid continues to accumulate as long as the brain can be readily displaced or compressed.

4. Penfield, W. G.: The Cranial Subdural Space: A Method of Study, Anat. Rec. **28**:173-175 (July) 1924; Chronic Meningeal (Post-Traumatic) Headache and Its Specific Treatment by Lumbar Air Insufflation: Encephalography, Surg., Gynec. & Obst. **45**:747-759 (Dec.) 1927.

After the fluid enters the space, it becomes locked, for little or no absorption takes place. The locking process is undoubtedly due to cerebral edema which forces the brain into the arachnoid opening, thus blocking the return to the subarachnoid spaces for absorption. The collection of fluid acts as a foreign body and produces local and diffuse pressure, which interferes with cerebral circulation and gives rise to local and general neurologic symptoms. In the early phase of the lesion the fluid may contain a trace of blood, while in the chronic stage the blood has disappeared and the fluid contains xanthine and is pale yellow. In none of our cases did the fluid appear like the chocolate brown fluid of a subdural hematoma. However, it is possible for both lesions to coexist.

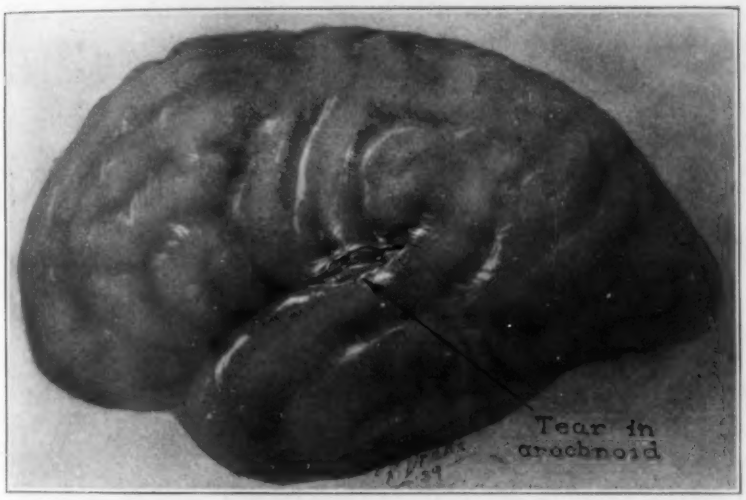


Fig. 2.—Tear in arachnoid which permitted escape of cerebrospinal fluid into subdural space.

The term "hydroma" proposed by Dandy [5] describes the lesion better than other terms that have been used, for the lesion is not a true cyst nor has it been initiated by meningitis and arachnoiditis. Munro and Merritt [6] were of the opinion that a subdural hydroma is only a phase of a subdural hematoma. They stated that subdural hematomas are of three types: (1) solid, (2) mixed and (3) fluid. Hematomas of the last type they

5. Dandy, W. E.: Chronic Subdural Hydroma and Serous Meningitis (Pachymeningitis Serosa: Localized External Hydrocephalus), in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, Inc., 1940, vol. 12, chap. 11, pp. 306-310.

6. Munro, D., and Merritt, H. H.: Surgical Pathology of Subdural Hematoma, Based on a Study of One Hundred and Five Cases, Arch. Neurol. & Psychiat. **35**:64-78 (Jan.) 1936.

divided into two subgroups: (1) those in which the subdural collection of fluid consisted of a minimum of blood and a maximum of cerebrospinal fluid and (2) those in which there was only residual clear fluid because the original clots had completely dissolved during the time elapsed between the injury and the operative evacuation of the cyst. They stated that the increase of volume results from osmotic change. Gardner [7] in experimental studies confirmed the dialyzing role of the arachnoid.

As we have stated previously, we believe that subdural hydroma and subdural hematoma may coexist and that when this happens the blood is diluted with cerebrospinal fluid, but it is our opinion that they are two separate lesions and arise from separate causes. The arachnoid undoubtedly acts as a dialyzing membrane and permits the osmotic exchange which accounts for the fluid in a chronic subdural hematoma. In our experience [8] hydromas have been present from one day to several weeks

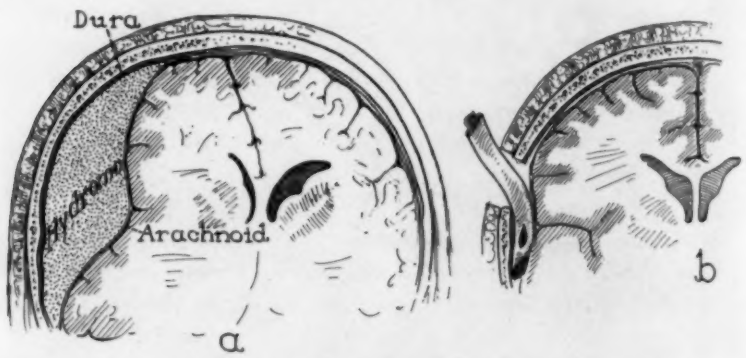


Fig. 3.—(*a*) Displacement of cerebrum with distortion of ventricle by hydroma; (*b*) drainage of hydroma with replacement of cerebral structures.

and subdural hematomas for many months before the patients present themselves for examination. Therefore, we are compelled to conclude that the hydromas were due to accumulation of cerebrospinal fluid in the subdural space and not to disintegration of blood clot, since the hydromas of a few hours' duration did not have sufficient time to develop from degeneration of blood clot. This opinion is substantiated by the case in which we demonstrated the tear in the arachnoid and the escape of fluid in the region of the sylvian fissure.

The fluid between the arachnoid and the dura may remain free or may become encapsulated with a thin membrane (fig. 3). When the hydroma

7. Gardner, W. J.: Traumatic Subdural Hematoma with Particular Reference to the Latent Interval, Arch. Neurol. & Psychiat. **27**:847-858 (April) 1932.

8. Adson, A. W.: Head Injuries, South. M. J. **32**:926-933 (Sept.) 1939. Love, J. G.: Bilateral Chronic Subdural Hydroma, J. Nerv. & Ment. Dis. **85**: 161-166 (Feb.) 1937.

has been of long duration, the membrane becomes thicker, although never so thick as the membrane of a subdural hematoma. The fluid has been known to coagulate when the protein content was excessively high. In the cases of Cornwall [2] and Abercrombie [2] postmortem examination revealed a voluminous semisolid mass, compressing the convexity of one hemisphere.

The subdural hydroma is more often unilateral than bilateral and invariably extends upward over the hemisphere from the sylvian fissure, but it may extend into the middle fossa. The quantity of fluid is variable. In one of Payr's cases the hydroma contained more than a pint (500 cc.) of cerebrospinal fluid, but usually only a few ounces are found. The fluid usually is under tension and may be clear, yellowish or tinged with blood in cases in which the injury has been recent. The trace of blood corresponds to the amount present in the cerebrospinal fluid. The protein content of the fluid is usually increased. In a case in our series the concentration of protein was 140 mg. per hundred cubic centimeters. Subdural hydroma is said to occur frequently, at least as frequently as acute subdural hematoma. This is not true in our groups. Owing to the larger incidence of trauma among men, hydroma is more frequent among them than among women, although it can occur in any sex or at any age.

SYMPTOMS

The symptoms and clinical findings of subdural hydroma are the same as those of subdural hematoma and are, in short, those of cerebral compression after cranial trauma. Since the subdural hydroma acts as a space-occupying lesion, focal signs such as hemiparesis, hemiplegia, aphasia, increased contralateral reflexes, unilateral mydriasis and jacksonian epileptiform attacks may develop. At other times, only symptoms of increased intracranial pressure are present, such as headache, irritability, vomiting, disorientation, grand mal convulsions, semistupor or coma, bradycardia and choked disks. However, the outstanding symptom is the headache. This is more or less severe, sharp, resistant to the usual sedatives, generalized or localized in the frontal region, behind the eyes or at the site of trauma. The headache occasionally assumes the form of hemicrania. As with subdural hematoma, mental changes varying from slight irritability or anxiety neurosis to complete dementia may develop as a result of the increased pressure or the damage of the brain with the consequent post-traumatic cortical atrophy. Focal and generalized symptoms may coexist at the same time. The symptoms, even the mental changes, may develop immediately after the injury, as in the case reported by Faure-Beaulieu and Brun,[9] or they may appear after a free interval

9. Faure-Beaulieu and Brun: Le tréponème dans les adénopathies satellites d'arthropathies, tabétiques, abstracted, Presse méd. **1**:42 (Feb. 17) 1932.

of longer or shorter duration, varying from hours to weeks. It is true that the free interval frequently is more apparent than real, since the patient always complains of some headache and a vague and indefinite malaise.

Roentgenograms usually do not reveal any positive sign, except possibly a previously overlooked fracture. Encephalography does not present any specific signs except the fluid level (fig. 4) or the signs described

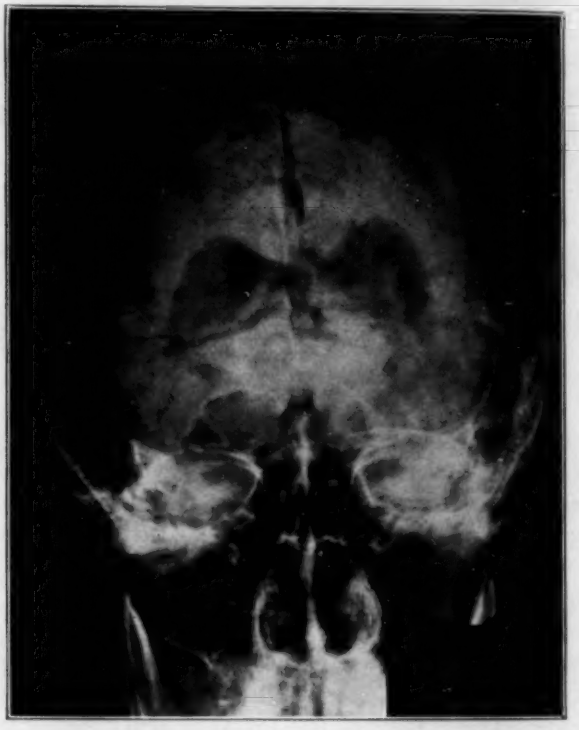


Fig. 4.—Encephalogram illustrating fluid level and spinal drainage in left parietal region.

by Dandy,[5] Dyke [10a] and Dyke and Davidoff [10b] as common to the subdural hematoma.

Encephalograms reveal displacement of the ventricles and reduction in their size on the side of the lesion, that is, the signs of a space-taking

10. (*a*) Dyke, C. G.: Pathognomonic Encephalographic Sign of Subdural Hematoma, Bull. Neurol. Inst. New York **5**:135-140 (Aug.) 1936. (*b*) Dyke, C. G., and Davidoff, L. M.: Chronic Subdural Hematoma: A Roentgenographic and Pneumoencephalographic Study, ibid. **7**:112-147 (Sept.) 1938.

lesion, with little if any air in the subarachnoid spaces at the site of the lesion.

In the differential diagnosis, brain tumor, chronic abscess and localized meningitis must be considered and ruled out. To differentiate subdural hydroma from subdural hematoma is practically impossible, and the diagnosis often is made only at exploratory operation. As occasionally has happened in cases of subdural hematoma, the condition which has been diagnosed as brain tumor has been found at operation to be subdural hydroma.

In order to emphasize the sequence of events in the development of symptoms of patients suffering from subdural hydroma, we wish to include a detailed report of an illustrative case which Walsh and Shelden [11] presented at the meeting of the general staff of the Mayo Clinic.

REPORT OF A CASE

A boy 9 years of age had been thrown from his pony two days prior to admission to the Mayo Clinic. The injury took place about noon. When he was found a little later, he was unconscious and lying on his face. There was no evidence of bleeding or fractures. On being taken to his home, he regained consciousness in about an hour. However, he continued to remain drowsy and vomited, but the emesis contained no blood. He was taken to a hospital, where it was determined that his left arm and leg were partially paralyzed. On questioning, the mother stated that the paresis was less marked at the time he regained consciousness than it was at 4:30 p. m., the hour he arrived at the hospital. During the night of the first day in the hospital the boy could be aroused, although he was drowsy. The vomiting ceased, and he complained of no pain. The following day the left arm and hand appeared to be weaker than they were the day of the injury. His drowsiness had abated somewhat. Because of the symptoms he was referred to the clinic.

On admission to the clinic and hospital the patient presented left hemiparesis of the entire side, including the face. The paresis of the face was graded as 2, on a grading basis of 1 to 4, in which 1 designates the mildest and 4 the most severe condition. The paresis of the upper extremity was graded 3 and the paresis of the lower extremity was graded 1 plus. Patellar and achilles tendon reflexes were exaggerated on the left side, and the Babinski reflex was positive. Examinations of the urine and blood gave negative results. Roentgenograms of the cervical portion of the spinal column and head revealed nothing abnormal. The examination of the ocular fundi did not reveal choked disks.

Surgical Findings.—In view of the history and findings a tentative diagnosis of subdural hydroma or subdural hematoma was made, and an exploratory operation through a temporal decompression was advised and performed. The dura was uncovered in the right temporoparietal region and was found to be tense; there was no evidence of pulsations or discoloration. On perforation of the dura, blood-tinged cerebrospinal fluid spurted out. Further opening of the dura revealed a large lake of blood-tinged fluid between the dura and the arachnoid, which had

11. Walsh, M. N., and Shelden, C. H.: Acute Subdural Hydroma: Report of a Case, Proc. Staff Meet., Mayo Clin. **12**:134-135 (March 3) 1937.

compressed the temporal, parietal and frontal lobes on the right side. After removal of this fluid, an illuminated retractor was introduced into the cavity in search of the rent in the arachnoid. This was found in the region of the sylvian fissure, opposite the outer margin of the wing of the sphenoid, where the arachnoid is occasionally attached to the dura (fig. 2). The opening in the arachnoid was about a centimeter in length; from this could be seen further escape of cerebrospinal fluid. Approximately 4 ounces (120 cc.) of cerebrospinal fluid was removed. As soon as the pressure had been relieved by the withdrawal of the fluid, pulsations in the cerebral artery could be seen. To remove any subsequent collection of fluid while the ventricles refilled and the brain was being replaced, a Penrose wick, a strip of gauze introduced into a Penrose drain, was inserted into the wound and left in place for four days (fig. 3*b*).

Subsequent Course.—During the time the drain was in place, the patient was encouraged to drink all of the fluid possible in the hope of encouraging refilling of the ventricle, replacement of the brain and obliteration of the arachnoid opening.

Convalescence was uneventful, and the wound healed by primary union. The day after the operation, the boy was much more alert than he had been prior to the operation, and the hemiparesis began to disappear. On the eighth postoperative day normal function had returned to the foot and arm, but the face and hand still showed evidence of motor weakness. On the ninth day the recovery of function in the hand and face returned overnight. He was dismissed on the fifteenth day after admission with recovery of function, except continued evidence of slight incoordination of his fingers and a slight limp on walking alone. A subsequent report from the parents indicated that complete recovery was made.

SURGICAL CONSIDERATIONS

Single or multiple trephine openings for the evacuation of encysted fluid between the dura and the arachnoid are indicated when a patient has sustained an injury of the head from which he does not promptly recover. This is especially true when the pneumoencephalographic study suggests a flattening of one or both cerebral hemispheres, with little or no air in the subarachnoid spaces in the temporoparietal region. Persistent headache after an injury is frequently the result of a subdural hematoma or a subdural hydroma and, we believe, justifies making exploratory trephine openings over the site of involvement. Occasionally, it is possible to drain this collection of fluid through a single trephine opening. However, if a large collection of fluid with marked depression of the brain is present, it is wiser to make two trephine openings over the affected hemisphere, placing one near the midline over the premotor portion of the brain and the second in the temporal region. Through and through drainage is achieved by introducing a no. 19 French catheter; this is left in place from three to five days, or until the lateral ventricles have expanded to their normal size and the space between the dura and the arachnoid has become obliterated. Although a hydroma is more often unilateral than bilateral, it usually is wise to place a trephine opening on the opposite side in a position similar to the one made over the frontal

lobe in order to make sure not to overlook a bilateral lesion. Occasionally, hydroma has a tendency to reform as in Cohen's case.[12] If this should occur, redrainage or longer continuous drainage through the temporal trephine opening will be necessary. Other procedures, such as the employment of osteoplastic flap and repeated drainage by aspiration, have been employed.

The operative results depend on the duration and the severity of the symptoms. Patients who have had symptoms of short duration without destructive cerebral changes make complete recoveries.

---

12. Cohen, I.: Chronic Subdural Accumulations of Cerebrospinal Fluid After Cranial Trauma: Report of a Case, Arch. Neurol. & Psychiat. **18**:709-723 (Nov.) 1927.

CESSATION OF RESPIRATORY EXCHANGE

W. H. CASSELS, M.D.
CHICAGO

In observing the artificial state of disturbed function known as anesthesia, the anesthetist has almost constant occasion to study respiratory problems, which in other branches of medicine are encountered so infrequently as to prevent familiarity. It therefore seems to be within the anesthetist's province to offer his views on this subject. The term "cessation of respiratory exchange" is used here to refer to the complete interruption of the flow of air into and out of the lungs.

That adequate respiratory exchange is essential to life is an axiom of physiology. The layman has heard that the proof of death is to hold a mirror in front of the nose and mouth and demonstrate the absence of respiratory exchange. Even some doctors regard cessation of respiratory exchange as synonymous with death. A physician, once called to treat a person who had taken an overdose of morphine, arrived to find the patient, as he said, "already dead," although "the heart was still beating." The surest way to alarm a surgeon is to tell him that his patient is not breathing. Interrupted in the midst of a trying surgical procedure and knowing practically nothing about the preceding circumstances, the surgeon is in a dilemma, and it is not surprising that he frequently orders the administration of unavailing drugs and fails to employ the mechanical measures which might lead to successful diagnosis and treatment of the condition.

It is not the purpose of this paper to increase the alarm but rather to emphasize that cessation of respiratory exchange need not be fatal, provided it is promptly recognized, quickly investigated and judiciously treated. Failure to breathe is no more synonymous with death than is failure to eat. Either condition, if allowed to persist, will cause death from deprivation. The fact that deprivation of oxygen will cause death within seconds or minutes, while deprivation of food will cause death within days or weeks, does not alter the fundamental accuracy of this analogy. One may even point out that the urgency in each case depends on the reserve supply of certain substances in the body at the time. A debilitated patient cannot withstand starvation as long as one who is well nourished. A patient with a subnormal amount of oxygen in the blood and lungs will quickly

From the Division of Anesthesia, University of Illinois College of Medicine.

succumb to cessation of respiration. On the other hand, I have seen one who had been breathing a mixture rich in oxygen live for fourteen minutes after sudden cessation of respiratory exchange. During nearly twelve minutes his original condition could almost certainly have been restored had respiratory exchange been successfully reestablished.

The conclusion is obvious. In case of cessation of respiratory exchange, supply oxygen (air) and save the life. This elementary principle is too often overlooked in the confusion of more advanced knowledge; or if the principle is recognized, its application may fail for lack of precise understanding of the mechanical factors involved.

Respiratory exchange is a mechanical function, and interference with it should be considered as a mechanical problem and treated by mechanical means. Such a viewpoint simplifies the problems of quick diagnosis and treatment required in an emergency. On a mechanical basis the instances of cessation of respiratory exchange may be divided into three classes dependent on three types of this condition.

TYPES OF CESSATION OF RESPIRATORY EXCHANGE

1. *Cessation of Respiratory Effort Without Obstruction.*—This is recognized by absence of spontaneous movement of the chest and abdomen, while efficient artificial respiration can inflate the chest, demonstrating the freedom of the air passages. It may be caused: (*a*) by paralysis of the muscles of respiration; (*b*) by excessive elimination of carbon dioxide; (*c*) by reflex inhibition, as from stimulation of the carotid sinus; (*d*) by paralysis of the respiratory center from intracranial lesions, from an overdose of sedative drugs, such as anesthetics, or from acute oxygen want. Acute oxygen want is a common sequel to other forms of cessation of respiration, or it may result from the inhalation of an atmosphere too low in oxygen. Another cause of acute oxygen want of the respiratory center always to be considered is cessation of circulation. If cardiac arrest preceded respiratory arrest, resuscitative efforts should be directed primarily toward reestablishing the circulation. This condition, however, is much less common and recovery much less likely. Indeed, there has been in the past too much emphasis on stimulation of circulation and too little emphasis on restoration of proper oxygenation. If all patients were efficiently treated on a respiratory basis, those saved would far outnumber those lost from failure to stimulate the circulation.

The immediate treatment for cessation of respiratory effort is the establishment of efficient artificial respiration. This should be accompanied by efforts to eliminate the cause. In case of an overdose of an inhalation anesthetic agent, one must provide for a free escape of exhaled gases rather than allow rebreathing of them in a closed system.

In attempting artificial respiration it is important to observe whether respiratory exchange is actually being produced. If respiratory exchange is not being successfully produced in spite of efficient efforts, the case probably belongs in the third class.

2. *Obstruction to Respiration Without Cessation of Respiratory Effort.*—This is recognized by failure to get air into or out of the lungs while active respiratory movements persist. There is a characteristic appearance to this type of futile respiratory effort with which every doctor should be familiar. The abdomen expands at the expense of the chest. It is simulated by the paradoxic "rocking boat" type of breathing caused by complete intercostal paralysis. One danger is that in the presence of respiratory efforts, the cessation of exchange may pass unnoticed until acute oxygen want becomes evident.

The causes of obstruction are so numerous that only a few examples can be mentioned here: (1) relaxation of the muscles of the jaw, as in coma or anesthesia, may permit the tongue to fall back against the posterior wall of the pharynx; (2) foreign bodies in the throat, larynx or trachea, such as chewing gum, false teeth, meat, candy, sponges, mucus, vomitus, blood or pus; (3) laryngospasm caused by local irritation or reflex stimulation; (4) tumors or edema encroaching on the respiratory passages; (5) external pressure on the neck or chest, caused perhaps by poorly fitting casts or by the weight of an intern's arm on the neck or chest of an infant.

In the treatment of obstruction, naturally the cause should be removed if possible. Pharyngeal obstruction caused by the tongue falling back may be relieved by elevating the head on a pillow and pulling the jaw forward. A semiprone position may accomplish the same result by gravity. Insertion of a good pharyngeal airway is one of the best methods of treatment. One might say without exaggeration that a good pharyngeal airway is the most valuable device in the anesthetist's armamentarium. Foreign bodies may be removed by gravity, suction, digital manipulation or instrumentation. Laryngospasm, tumors and many of the other forms of obstruction may in most cases be dealt with efficiently for the moment by the insertion of an endotracheal tube. Any obstruction at or above the larynx may be relieved by a quick tracheotomy, but other methods are preferable if they can be used successfully. In cases of obstruction it is well to remember that some air can usually be forced past the obstruction by methods of positive pressure, such as mouth to mouth breathing.

The oxygen want resulting from obstruction may become sufficiently acute to cause paralysis of the respiratory center. The case then fits into the third class.

3. *Cessation of Respiratory Effort and Obstruction to Respiration.*—This condition is recognized by absence of respiratory movements and

failure of efficient artificial respiration to produce respiratory exchange. It is caused by some combination of the causes listed for the first and second types, most commonly by acute oxygen want following obstruction or by pharyngeal relaxation resulting from the same depression which causes paralysis of the respiratory center. The first necessity is to relieve the obstruction. Then, since the patient will not resume spontaneous breathing, artificial respiration must be instituted.

REPORT OF A CASE ILLUSTRATIVE OF ALL THREE TYPES

A patient with a retropharyngeal abscess already discharging pus into the pharynx was to have the abscess drained through an external incision. As soon as anesthesia was induced, severe respiratory obstruction developed, although respiratory efforts continued (type 2). Insertion of a pharyngeal airway failed to relieve the effects of the obstruction. Signs of oxygen want were becoming rapidly apparent. An endotracheal tube was inserted with difficulty because of the swelling and distortion of the pharynx. Before this was accomplished, efforts to breathe had stopped because of acute oxygen want (type 3). The lungs were inflated several times through the endotracheal tube, and spontaneous respirations were resumed. Soon after the operation started, breathing again stopped. This time there was, of course, no obstruction (type 1). Artificial respiration by intermittent pressure on the bag had to be maintained throughout the operation, but when the surgical procedure was completed spontaneous respirations were resumed. The assumption was that cessation of respiratory exchange was due to pressure on the carotid sinus.

METHODS OF ARTIFICIAL RESPIRATION

Nearly every doctor is familiar with some methods of artificial respiration, usually the manual methods of Schafer and Sylvester. Some other methods are even more applicable in many cases. One of the quickest, most readily available and most efficient methods is that of mouth to mouth or that of mouth to nose respiration, in which the operator blows his own breath with 16 per cent oxygen into the patient. If a piece of gauze or a clean handkerchief is placed over the mouth and nose of the patient, one's esthetic senses need not be seriously offended. Most anesthetic machines with a bag, mask and oxygen tank provide a convenient means of inflating the lungs by positive pressure.

STIMULANTS

The administration of analeptics, of inhalations of carbon dioxide or of intracardiac injections of epinephrine hydrochloride is of little or no value in cases of cessation of respiratory exchange and in some cases is dangerous. In the absence of proper oxygenation the agents named will rarely stimulate the respiratory center, and they certainly can have no beneficial effect on obstruction. During respiratory arrest there is already excess carbon dioxide accumulating in the blood, and the administrtaion of additional carbon dioxide is generally useless

and probably harmful. Intracardiac injections have no indication in relation to respiratory difficulties, and they may cause ventricular fibrillation in a heart which is still efficient.

Finally, it would be in the interests of the reputation and standing of members of the medical profession if every graduate in medicine were sufficiently capable of dealing with acute respiratory emergencies that he would not have to call on the fire department to do his work for him.

SUMMARY

Cessation of respiratory exchange need rarely prove fatal if it is promptly recognized, quickly investigated and judiciously treated.

The problem of supplying oxygen (air) to the lungs should be regarded as a mechanical one. On this basis, instances of the condition may be divided into three classes dependent on three types of difficulty: (1) cessation of respiratory effort without obstruction, in which efficient artificial respiration will inflate the lungs; (2) obstruction without cessation of respiratory effort, in which relief of the obstruction will permit spontaneous respiration; (3) cessation of respiratory effort with obstruction, in which relief of the obstruction must be followed by artificial respiration.

The physician treating the patient should not depend on the use of stimulant drugs or carbon dioxide or on the aid of the fire department.

THE BLADDER OF WOMEN AFTER OPERATION

CHARLES LINTGEN, M.D.
PHILADELPHIA

These studies were undertaken in an attempt to answer several puzzling questions: (1) whether or not patients having micro-organisms in the urine of the bladder before operations involving the bladder are more likely to have postoperative complications and pyelitis than are those having no organisms in the bladder; (2) whether any relationship exists between the duration of operation and of anesthesia and the incidence of postoperative catheterization; (3) whether there is any relationship between postoperative catheterization, complications involving the bladder and morbidity.

The close anatomic relationship between the bladder, the vagina, the cervix and the fundus of the uterus makes the bladder vulnerable to injury in certain types of operations. Anterior colporrhaphy involves the separation of the vaginal tissues from the anterior surface of the bladder and from the trigonal region, which is more closely attached at the cervical area. The same procedure is carried out in the Watkins interposition operation, in the Fothergill (Manchester) operation and in vaginal hysterectomy. In abdominal supravaginal and complete hysterectomy, the bladder is manipulated in separating it from the anterior surface of the uterus but to a lesser extent than in vaginal repair.

Various investigators have shown that the normal bladder of women may harbor bacteria without the development of any disease. Murray [1] of Liverpool found an incidence of 42 per cent positive cultures made from material from the bladders taken in the operating room of patients who had no urinary symptoms before operation. Not being satisfied with these results, he performed intra-abdominal puncture of the bladder in a series of 12 patients and obtained urine yielding positive cultures in 25 per cent.

The contributions of Curtis and Taussig [2] to the knowledge of the postoperative bladder are well known to all gynecologists. Both these observers attempted to show that residual urine was the principal causa-

From the Department of Gynecology, Jefferson Medical College Hospital.

1. Williams, R. S.; Murray, H. L., and Wallace, A. J.: J. Obst. & Gynec. Brit. Emp. **22**:65, 1912.

(Footnotes continued on next page)

tive factor in the production of postoperative infection of the bladder. Prior to these investigations, surgeons were rather reluctant to catheterize patients after operation, until more or less distention and discomfort had occurred.

In this field of clinical investigation, Hale-White [3] should also be mentioned. He first expressed the belief that micro-organisms were not present in the urine unless there were symptoms either referable to the urinary tract or manifested by general infection. In a later paper, however, Hale-White [4] modified his view, saying that the mere presence of colon bacilli in the urine is not necessarily productive of urinary symptoms.

It should likewise be mentioned that Williams,[5] in 1912, made a study of patients which seemed to indicate that passage of colon bacilli in the urine was a late stage of chronic intestinal disorder and that when the intestinal condition subsided the bacilluria disappeared.

David [6] presented a paper in 1918 showing that the injection of colon bacilli into the nonobstructed, nontraumatized bladder is not followed by cellular exudation in the submucosa or muscularis mucosae.

My investigation comprises a study of 100 patients who were subjected to major operative procedures. These procedures consisted of plastic work on the cervix or on the anterior or the posterior vaginal wall, or a combination of these, i. e., plastic operations and sections, or simply abdominal sections. Minor operations or radium implantations were not considered in this study, since the effect of the radium alone on the mucosa of the bladder may be sufficient to produce postoperative symptoms. Patients having definite urologic symptoms or those having preoperative urine with pathologic findings aside from the culture were not included in my study.

Because the term "cystitis" is vague and often loosely applied, I prefer to employ the term "postoperative pyuria," since some patients who evidence pyuria due to inflammation of the mucosa of the bladder do not have the usual train of symptoms associated with or thought to be synonymous with the condition known as cystitis; neither do I subject my patients to routine postoperative cystoscopic examination merely because pyuria of varying degree, or possibly dysuria, is present. Nevertheless, the specific diagnosis of cystitis cannot be made without inspecting

2. (*a*) Curtis, A. H.: Surg., Gynec. & Obst. **29**:24, 1919; (*b*) Management of Female Urinary Bladder After Operation and During Pregnancy: A Further Study of Residual Urine in Its Bearing on Urinary Tract Disturbances, J. A. M. A. **80**:1126 (April 21) 1923; (*c*) Surg., Gynec. & Obst. **40**:689, 1925. (*d*) Taussig, F. J.: Tr. Am. Gynec. Soc. **40**:351, 1915.

3. Hale-White, W.: Lancet **2**:1203, 1912.

4. Hale-White, W.: Lancet **1**:1237, 1922.

5. Williams, E. M.: Lancet **2**:511, 1912.

6. David, V.: Surg., Gynec. & Obst. **26**:159, 1918.

the bladder through the cystoscope, even though there are frequency of urination, dysuria or pyuria. A cystoscopic examination should be made of those patients in whom pyuria or urologic symptoms persist.

Twenty-four patients out of the 100 included in this study were found to have a positive preoperative culture. Table 1 indicates the types of organisms recovered.

TABLE 1.—*Types of Organisms Found in Preoperative Cultures of the Urine of Twenty-Four Patients*

Bacillus coli communis	11
Staphylococcus albus	4
Diphtheroid bacillus	2
Streptococcus haemolyticus	1
Micrococcus ureae	2
Bacillus subtilis	1
Streptococcus nonhaemolyticus	1
Staphylococcus aureus	1
Bacillus proteus	1
	24

TABLE 2.—*Postoperative Course of Patients Who Had Positive Cultures Before Operation*

Patients with positive preoperative cultures	24
Patients with positive postoperative cultures	19
Patients with same kind of culture before and after operation	10
Patients catheterized	15 (62.5%)
Patients in whom postoperative pyuria developed	14 (58.3%)
Patients in whom postoperative pyelitis developed	0
Postoperative hospital days	18

TABLE 3.—*Postoperative Course of Patients with Positive Preoperative and Postoperative Cultures Yielding Same Type of Organism*

Patients with positive operative cultures	10
Patients in whom pyuria developed	8 (80%)
Patients catheterized	7 (70%)
Patients in whom postoperative pyelitis developed	0
Postoperative hospital days	18

The specimen for study was collected in a sterile container in the operating room after the introitus and urethral meatus had been carefully cleansed with solutions of soap, water and mercury bichloride (1 in 1,000), and it was immediately sent to the laboratory for study.

Of the 24 patients who had positive preoperative cultures, 19 had positive postoperative cultures, 10 of whom had the same organisms in the postoperative as in the preoperative cultures. Fifteen patients of the 24 (62.5 per cent) were catheterized after operation. In 14 patients

(58.3 per cent) postoperative pyuria developed; 10 of them were catheterized. Pyelitis developed in none of this group, but complications other than urologic ones developed in 3.

On further analysis of the cases of the 10 patients with the same type of preoperative and postoperative cultures, we find that 7 (70 per cent) of them were catheterized and that pyuria developed in 8 (80 per cent) of them, 5 of whom were catheterized. However, only 2 patients of this group had symptoms suggestive of cystitis, and the average number of postoperative days spent in the hospital was eighteen.

A total of 76 patients out of the series of 100 had negative cultures before operation. After operation, however, positive cultures were obtained for 39 of this group. The predominating organisms were

TABLE 4.—*Postoperative Course of Patients with Negative Preoperative Cultures*

Patients with negative preoperative cultures	76
Patients with positive postoperative cultures	39
Patients catheterized	56 (80%)
Patients in whom postoperative pyuria developed	28 (40%)
Patients in whom postoperative pyelitis developed	2 (2.0%)
Postoperative hospital days	19

TABLE 5.—*Postoperative Course of Patients with Negative Cultures Before and After Operation*

Patients with negative cultures before and after operation	36
Patients catheterized	22 (78%)
Patients in whom postoperative pyuria developed	5 (13.9%)
Patients in whom postoperative pyelitis developed	1 (2.7%)
Postoperative hospital days	18

B. coli communis and Staph. albus. Fifty-six patients (80 per cent) of the series required catheterization; postoperative pyuria developed in 28 (40 per cent), and 34 of these were catheterized. Although a higher percentage of this group with negative cultures was catheterized, pyuria developed in a relatively smaller number of them than in those who had positive preoperative cultures. Postoperative pyelitis definitely developed in 2 patients of this group. Five patients in this group complained of symptoms suggesting cystitis. The average number of postoperative hospital days was nineteen.

Thirty-six patients in the series of 100 patients had negative cultures before and after operation. Twenty-two (78 per cent) of this group of 36 were catheterized, but postoperative pyuria developed in only 5 (13.9 per cent) and pyelitis in only 1. The average number of postoperative hospital days for the group was eighteen.

Table 6 is a composite picture of tables 2, 4 and 5, relative to postoperative pyuria.

Catheterization was required much more frequently when plastic operations had been performed than when the operations consisted of abdominal sections. This should be expected, but there was not a great difference in the incidence of pyuria. In other words, although the patients who had plastic operations were catheterized much more fre-

TABLE 6.—*Postoperative Pyuria*

Patients with positive preoperative cultures in whom postoperative pyuria developed	14 (58.3%)
Patients with negative preoperative cultures in whom postoperative pyuria developed	28 (40%)
Patients with negative preoperative and negative postoperative cultures in whom postoperative pyuria developed	5 (13.9%)

TABLE 7.—*Incidence of Pyuria According to Type of Operation*

Type of Operation	Patients	Patients Catheterized	Postoperative Days in Hospital	Patients with Pyuria
Plastic operations	30	27 (90%)	16.1	13 (43.3%)
Abdominal sections	70	49 (70%)	21	33 (45.7%)

TABLE 8.—*Incidence of Pyuria According to Catheterization*

	Total Number	Number with Postoperative Pyuria
Patients catheterized	77	49 (61%)
Patients not catheterized	23	6 (26%)

TABLE 9.—*Relation of Length of Time Patients Were Subjected to Ether Anesthesia to Number of Catheterizations*

Time (Min.)	Patients	Patients Catheterized	Per Cent Catheterized
60 or less	12	10	83.3
60 to 120	47	38	78.3
120 to 180	26	19	73.3

quently than were those who had abdominal sections, pyuria did not develop in the former group as frequently as in the latter.

Seventy-seven patients of the 100 were catheterized one or more times. Pyuria developed in 49 (61 per cent). Eight patients were catheterized only once; 6, twice, and the others, more frequently. However, pyuria developed in only 6 (26 per cent) of the 23 patients who were not catheterized.

It has frequently been stated that the longer a patient is subjected to general anesthesia, the greater is the possibility that subsequent catheterization will be necessary. From my observations this appears

rather questionable. Of 12 patients on whom operations lasting sixty minutes or less were performed, 83.3 per cent were catheterized, while in 78.3 per cent of 47 patients catheterizations followed operations lasting sixty to one hundred and twenty minutes, and only 73.3 per cent of 26 patients required catheterizations following operations lasting one hundred and twenty to one hundred and eighty minutes.

These observations, however, do not take into consideration the specific type of operation performed in each case.

Fifteen of the 100 patients had spinal anesthesia, and 11 (73.3 per cent) of these were catheterized. The operative procedures in this group consisted of plastic operations, plastic operations and sections, and straight abdominal sections.

Following Curtis'[7] suggestions, based on his experiments with animals, which tended to show that the unrelieved paralyzed bladder was a source of danger after operation, I have been liberal in my attitude toward catheterization. If a patient is unable to void eight hours after operation and the usual methods of trying to induce the patient to void are of no avail, the patient is catheterized. This procedure is then continued until the patient is herself able to empty her bladder completely.

I fully appreciate the arguments which might be urged against a study of this type because of the difficulty of obtaining urine from the bladder without contamination. It is entirely possible that the specimens from which some of my cultures were made might have been contaminated, but I feel that I created as sterile a field as possible under ordinary working conditions, for in any hospital service one has no better practical method of studying the bladder or kidney for pus and bacteria. Hence it is essential to know how much confidence one may place on the various findings mentioned.

SUMMARY

The presence of bacteria in the bladder before operation did not increase the incidence of postoperative pyelitis in this series of 100 patients. Patients with positive preoperative cultures seemed more liable to have pyuria than those with negative cultures.

Patients on whom plastic operations had been performed had to be catheterized more frequently than those on whom abdominal sections had been done.

Duration of anesthesia had some bearing on the frequency of required catheterization, but not as much as the specific type of operation, namely, plastic work.

Postoperative pyuria occurred more frequently after patients had been catheterized.

1930 Chestnut Street.

7. Curtis (footnotes 1 *a*, *b* and *c*).

SPECIFIC THERAPEUTIC SHOCK—THE HUGH YOUNG REACTION

WARD J. MacNEAL, M.D.
NEW YORK

In 1924 Young and Hill [1] described the remarkable clinical behavior of a few patients who responded favorably to the intravenous injection of mercurochrome. One of these, a man weighing about 68 Kg., had pyelonephritis and septicemia with heavy growth of colon bacilli in the blood culture. On Jan. 3, 1923, an intravenous injection of 34 cc. of a 1 per cent solution of mercurochrome was given. The temperature rose to 104 F. at midnight, but in six hours it had dropped to 97 F. The patient became rational, and on the next morning his condition was marvelously transformed, his temperature was normal, and his blood was sterile. He was discharged well on January 10.

Another man, weighing 59 Kg., with staphylococci in the blood stream, was given 10 cc. of a 1 per cent solution of mercurochrome intravenously. Following this, he had a chill, a rise of temperature above 105 F., with a fall to 102 F. in three hours and to 100 F. on the next day, and eventually recovered.

In 1925 Young [2] made a further report, illustrated by additional clinical charts. He said:

> Among 89 cases in which I have careful notes, there was a very severe reaction in three septicemia cases which seemed hopeless. The intravenous injection of mercurochrome was followed by a fearful chill, very high temperature, and the patient went into a condition of extreme shock. One became pulseless. But all three got well, and the reporters think the drug saved them.

Later in the same article he quoted Roeder and Judd [3] as follows:

> We have also noted that the greater the reaction obtained the more favorable the results: temperatures rising to 106-107.5, with the urine, vomitus, and frequent fecal movement colored with the dye may appear alarming, but in our experience

From the Department of Bacteriology, New York Post-Graduate Medical School and Hospital, Columbia University.

Presented at the meeting of the American Association of Pathologists and Bacteriologists in New York, April 11, 1941.

1. Young, H. H., and Hill, J. H.: The Treatment of Septicemia and Local Infections, J. A. M. A. **82**:669 (March 1) 1924.

2. Young, H. H.: The Treatment of Infections—General, Local and Urinary with Intravenous Injection of Mercurochrome, Surg., Gynec. & Obst. **40**:97 (Jan.) 1925.

3. Roeder, C. A., and Judd, W. H.: Mercurochrome Therapy, Nebraska M. J. **10**:41 (Feb.) 1925.

such patients have received the best results and have been harmed in no way with the exception of a salivation which has disappeared in a short time.

In my own experience the effective intravenous use of bacteriophages has frequently been associated with the production of a similar shock reaction, and this has been so often observed that I rely on the production of this reaction as an indication that adequate amounts of bacteriophage have been administered. One patient may react to a dose of 2 cc. or less, while another may require 1,000 cc. Hence administration of regularly spaced doses is advised until the chill is produced, and subsequently the therapy is continued with somewhat smaller doses at regular intervals.[4] The reaction has been observed in numerous patients suffering from septic staphylococcemia.[5] It is, however, also dramatic in the less common but highly dangerous invasion of the blood stream by colon bacilli.[6] In 1 of my patients with colon bacillus sepsis the temperature rose from 104 to 108 F. and fell to 97 F. in a period of eight hours; prompt convalescence followed.

When an antibacterial serum, such as that of a horse immunized against hemolytic streptococci, has been administered intravenously in divided doses to patients with hemolytic streptococci in the blood stream, I have observed a precisely similar behavior on the part of some of the patients.[7] I am inclined to think that this visible reaction is an indication of a turning of the balance in the fight between the bacteria, on the one hand, and the protective body fluids and phagocytic cells, on the other, probably due to an injury inflicted on the invading bacteria by the therapeutic agent, be it serum, phage or drug.

Undoubtedly this reaction has much in common with the ordinary spontaneous chill, sharp rise of temperature and sweat, so often repeated in untreated septic disease and in the earlier weeks of malaria. In its clinical character it closely resembles the shock induced by nonspecific foreign substances, such as intravenously injected triple vaccine (containing organisms of typhoid and the two paratyphoids). It differs, however, in this important respect, that it is brought about by the administration of an agent which is capable of exerting a direct specific antagonistic influence on the infecting microbe itself. The association of this reaction with intravenous therapy directed against the infecting microbe is something which belongs essentially to the more modern

4. MacNeal, W. J., and Frisbee, F. C.: Bacteriophage as a Therapeutic Agent in Staphylococcus Bacteremia, J. A. M. A. **99**:1150 (Oct. 1) 1932.

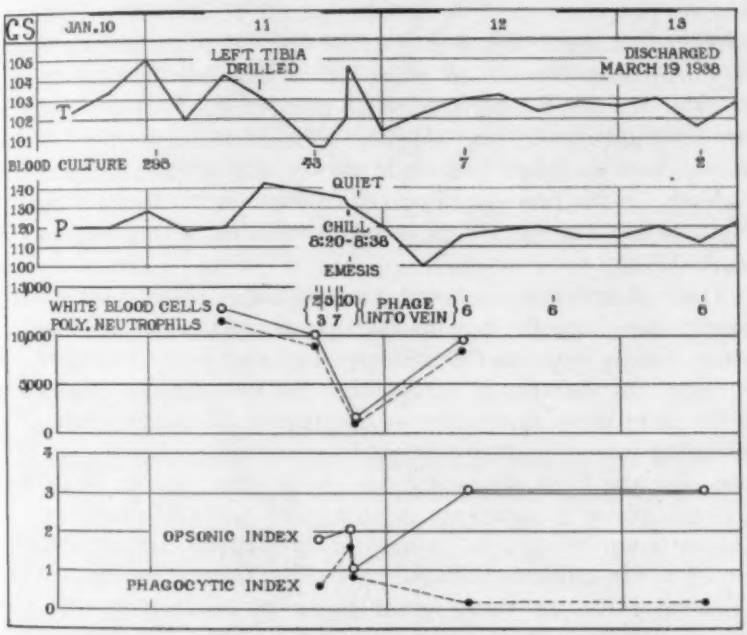
5. MacNeal, W. J.; Frisbee, F. C., and McRae, M. A.: Staphylococcemia 1931 to 1940: Five Hundred Patients, Am. J. Clin. Path., to be published.

6. MacNeal, W. J.: Therapeutic Use of Bacteriophages, Particularly in Sepsis, New York State J. Med. **39**:451 (March 1) 1939.

7. Sheplar, A. E.; Spence, M. J., and MacNeal, W. J.: Serum Therapy for Infections with Streptococci, Arch. Surg. **37**:772 (Nov.) 1938.

era in therapeutics, and my associates and I [7] have suggested that this group of phenomena, marking the successful culmination of a series of intravenous injections of an antibacterial agent, be designated as the Hugh Young reaction. A further proof of its character is furnished by the subsequent improvement in the clinical condition and the eventual recovery of the patient.

The chart illustrates the changes in the number of circulating leukocytes and in their phagocytic activity, as well as changes in the opsonic index, associated with the Hugh Young reaction in a patient



Temperature (*T*), pulse rate (*P*), blood counts, opsonic and phagocytic indexes of a patient (G. S.) with staphylococcemia, Jan. 10 to 13, 1938. The patient was an 8 year old boy. He was given 27 cc. of bacteriophage in divided intravenous doses between 5:05 and 7:47 p. m. on January 11; this produced mild shock with chill, associated with a remarkable decrease in circulating leukocytes and interesting alterations in the opsonic indexes, from 8:20 to 8:38 p. m. The boy was entirely well at the time of writing.

with staphylococcemia treated by intravenous injections of bacteriophage. This patient, a boy of 8 years, received stock staphylococcic phage intravenously on Jan. 11, 1938, in the following series: 2 cc. at 5:05 p. m.; 3 cc. at 5:45; 5 cc. at 6:26; 7 cc. at 7:11; 10 cc. at 7:47. A chill developed at 8:20 p. m.; it lasted eighteen minutes with a sharp rise of temperature to 104.6 F. at 8:38 and emesis of 300 cc. at 8:41.

A blood count taken at 9:03 p. m., just thirty minutes after the termination of the chill, revealed only 1,550 white cells and 992 polymorphonuclear neutrophils per cubic millimeter of blood, although the count taken at 5:03 p. m., just before the start of intravenous therapy, had shown 10,050 white cells and 8,894 polymorphonuclears and a count taken at 8:10 a. m. on the following day showed 9,600 white cells and 8,352 polymorphonuclears. The opsonic index, previously at 1.8, rose slightly during the intravenous therapy to 2.1 at 8:24 p. m. (just after the chill started at 8:20) and fell abruptly during the chill to 1.1 at 8:45 p. m., and rose to a high level, 3.1, on subsequent days. The comparative phagocytic activity of the patient's leukocytes (phagocytic index), which before treatment was 0.6 at 5:04 p. m., increased during the intravenous therapy to reach 1.6 at the beginning of the chill (8:24 p. m.) and fell abruptly to 0.8 at 8:45 p. m., after the chill had ceased. Subsequently the phagocytic index remained low until the bacteria were no longer present in the circulating blood (January 24). Evidently, in the presence of opsonized bacteria the leukocytes capable of phagocytic activity are to a considerable extent used up and lost from the blood.

These observations on human patients are in accord with studies of bacteriophage behavior in vitro and in experimental animals,[8] and they permit one to visualize the mechanism of the Hugh Young reaction. Evidently the therapeutic agent alters the infecting bacteria so as to render them more susceptible to phagocytosis (opsonic effect). The circulating leukocytes then take up these invading microbes, and at the same time the fixed phagocytic cells in the liver, spleen, lymph nodes and bone marrow participate in this more active phagocytosis. The phagocytic wandering cells, injured in this activity, are in turn phagocytosed by the reticuloendothelial cells of the internal organs, and hence a relative excess of young granulocytes of feeble phagocytic power remains in the circulating blood. The augmented destruction and digestion of bacteria and of host cells incident to this combat release various toxic substances to induce the chill and febrile reaction.

It is, however, quite probable that other, nonspecific (pyrogenic) substances may sometimes play a part and confuse the picture. Thus, the patient may be sensitive to the animal serum used, or the medium employed to dissolve the drug or that in which the bacteriophage is administered may itself contain such pyrogenic substances. Careful consideration should be given to these possibilities in each instance.

---

8. MacNeal, W. J.; Frisbee, F. C., and Slavkin, A. E.: Mechanism of Bacteriophage Action in Staphylococcus Bacteremia, Proc. Soc. Exper. Biol. & Med. **30**:12 (Oct.) 1932. MacNeal, W. J.; McRae, M. A., and Colmers, R. A.: Further Observations on Bacteriophage Action in the Presence of Blood, J. Infect. Dis. **63**:25 (July-Aug.) 1938.

ACUTE INTUSSUSCEPTION

CHARLES W. MAYO, M.D.
AND
ROBERT WOODRUFF, M.D.
Fellow in Surgery, Mayo Foundation
ROCHESTER, MINN.

Acute intussusception is a clinical and surgical emergency which can be completely and permanently cured by immediate and competent surgical intervention. On the other hand, tragedy often results if indecision and procrastination have occurred before the institution of treatment. Chronic intussusception more often than not is of secondary importance, and the primary pathologic process, usually a tumor, demands planned surgical attention.

One hundred and seventeen cases of intussusception in which operation was performed at the Mayo Clinic were reviewed. In 55 of these cases the condition was classified as acute intussusception. In this paper only data concerning the cases of acute intussusception are included. Thirty-eight of the patients were boys, and 17 were girls; this represents an incidence of 2.2 : 1.

Acute intussusception is primarily a disease of childhood, in contrast to the chronic process which nearly always manifests itself in adults. The youngest of our patients with acute intussusception was 24 days old; the oldest was 13 years of age. Thirty-six, or 65 per cent of the patients, were less than 1 year old, and 44, or 80 per cent, were less than 2 years of age.

In none of these cases was there any recurrence after surgical reduction. In 9 there had been recurrent mild attacks of abdominal cramps which finally ended in the acute process; in the other 46 cases, the acute episode marked the primary clinical attack. The recurrent attacks extended over periods of a few days to fourteen weeks before the onset of the acute symptoms that finally led to diagnosis and subsequent surgical treatment.

In all the cases in this series, as is usual in acute intussusception, the process was ileocolic; the intussusceptum or head of the process, starts in the terminal part of the ileum, moves into the cecum and thence, if the process continues, progresses up the ascending colon, on through the rest of the large bowel and may even present at the anal outlet.

From the Division of Surgery, Mayo Clinic.

CAUSE

According to the reports of others and our own judgment, it is unusual to find a definite pathologic basis for the event, with the exception of an occasional Meckel's diverticulum, which seemed to be the causative factor in 2 of our cases. The other 53 cases belong to that group in which there is no definite causative process.

Several explanations have been offered concerning the pathogenesis of this condition. The most tenable seems to be that fostered by Perrin and Lindsay.[1] The ileocecal valve of the infant projects ⅜ inch (1 cm.) into the cecum and the terminal part of the ileum receives a rich supply of lymph. Because of digestive disturbances, which are most likely to occur after the fifth month of life, when changes in diet are made, the lymphatic structures become swollen, and the terminal part of the ileum projecting into the cecum acts as an irritant. The increasing peristalsis results in intussusception. It is possible that the severe intestinal colic of children from which recovery is spontaneous may be an early stage of the process with spontaneous reduction and cessation. Another explanation is that the condition is purely neurogenic. Uncoordinated nervous impulses which contract the intestines here or there and stimulate peristalsis or antiperistalsis above or below the contracted part could easily lead to telescoping of the segment. Uncoordinated nervous impulses as a causative factor would also explain the rare retrograde or even the multiple intussusception. Either of these theories would certainly depend on the mobile terminal part of the ileum, cecum and colon, which is normally present in the infant.

SYMPTOMS AND DIAGNOSIS

The symptoms and findings in acute intussusception usually follow a rather stereotyped pattern. The diagnosis is not often an involved problem, but early diagnosis is of the utmost importance. In 11 of the 13 cases of this series in which death occurred, the patients had had definite symptoms for at least twenty-four hours before operation, while for many more than half the patients who survived diagnosis was made and operation was performed within twenty-four hours after the onset of acute symptoms.

The most constant and pathognomonic symptom is the characteristic intermittent colicky abdominal pain. In every one of the cases it marked the onset of the train of symptoms and findings that led to the ultimate diagnosis. In a typical instance, a healthy child suddenly will double up and cry out from severe pain, which after a few moments usually leaves as suddenly as it came. As the disease progresses, the attacks of pain

1. Perrin, W. S., and Lindsay, E. C.: Intussusception: Monograph Based on Four Hundred Cases, Brit. J. Surg. **9**: 46 (July) 1921.

continue at varied intervals. Vomiting is generally an early and prominent symptom of the disease. Shortly after the onset, the child may have a bowel movement which consists mostly of mucus and the feces that happen to be in the lower part of the bowel at that time. This usually is followed by spells of tenesmus and passage of mucus and blood. Bloody discharge from the rectum usually occurs at one time or another during the progress of the process. It may not be noted until it is seen on the examining finger of the physician, or it may have been seen in the returns of an enema administered by a frustrated parent trying to alleviate the pains of the suffering infant. In 43 of our cases either there was a history of blood or blood-tinged material being passed from the rectum, or blood was noted at the time of examination.

The patient who has acute intussusception is usually less than 2 years of age and of normal healthy development. Between colicky pains, the child generally lies quiet and for the most part is easy to examine. During the periodic attacks, however, the legs will be drawn up with pain. Careful abdominal and rectal examination usually will reveal a sausage-shaped mass in the right side of the abdomen. Failure to elicit a mass, however, does not rule out the diagnosis. In 15 of our cases a palpable mass was not noted on physical examination. After the child is anesthetized, it is not unusual to feel a mass which escaped detection in the preliminary examination.

The foregoing relates the typical chain of events. Intermittent colicky pains alone, without the other signs and symptoms of intussusception, should be looked on with suspicion, and progression of events into the typical picture of this pathologic process should demand prompt surgical intervention.

TREATMENT

It is our opinion, as well as that of the majority of those who come in contact with this disease, that prompt surgical intervention is the only rational treatment of this condition. There are still a few proponents of medical reduction through the use of intracolonic pressure by means of introduced barium sulfate, water, gas or other mediums. At best, those methods have a definite proportion of recurrences that demand later surgical treatment and, furthermore, it is impossible to know that the process has been entirely reduced. Delayed surgical intervention, owing to the failure of medical measures, will serve only to increase greatly the mortality.

Drop ether anesthesia is well accepted as the method of choice for infants. A right paramedian incision is made in the abdomen. In most of these cases the pathologic condition can be righted by simple manual reduction, that is, gentle milking from below upward with only the slightest traction on the proximal loop. In 44, or 80 per cent, of the cases

in this series reduction was accomplished by this method. If the process cannot be reduced completely because of edema of the tissues, cutting of the constricting neck of the intussusception with scissors and subsequent repair of the wall of the bowel, as described by Brown,[2] may well be considered. Gangrenous bowel, irreducible masses and marked obstruction demand separate attention, and we shall refer to these later.

Many different methods are described to prevent recurrences of the condition. Although recurrence is unusual after surgical reduction, the possibility must be kept in mind, and in each instance the decision must be made from the findings at operation whether some method of preventing recurrence should be adopted. In 16 of the cases in this series, simple reduction and nothing more was done. In 9 cases, after reduction the appendix with the ligated mesoappendix was brought out through a stab wound to serve as an anchoring point for the cecum. With this procedure, a catheter usually is introduced through the appendical stoma to serve as a decompression valve. The appendix usually sloughs off in eight to ten days, or it may be removed with the cautery when convenient. The resultant fistula closes spontaneously as a rule, or, if a little drainage persists, it may be necessary to destroy the lining of the mucous membrane with the cautery. This procedure will insure prompt closure. In 8 of our cases the terminal part of the ileum was sutured to the cecum or ascending colon after reduction to prevent recurrence. In 5 cases the mesentery was shortened and in 5 the cecum was stitched to the parietal peritoneum for the same purpose.

When gangrenous or necrotic bowel is encountered, either exteriorization or resection with primary anastomosis is indicated. The former seems to be the procedure of choice at most times. Primary anastomosis because of its attendant high mortality rate should be reserved for the rare occasion. The latter procedure was performed in 5 cases in this series with two deaths.

A fixed irreducible mass is probably best treated by a short-circuiting anastomosis. This was done successfully in 3 of our cases with no hospital mortality. Ileostomy alone or combined with one of the other procedures might be demanded when marked obstruction and distention are present. Two of our patients who underwent primary ileostomy subsequently passed sections of necrotic bowel through the rectum. The case of 1 of these patients was reported in detail elsewhere.[3] In both instances short-circuiting procedures were done later because of incomplete obstruction.

---

2. Brown, H. P., Jr.: Acute Intussusception in Children: Observations on Thirty-One Cases Admitted to the Children's Hospital in Philadelphia, Ann. Surg. **81**:637-645 (March) 1925.

3. Mayo, C. W.: Acute Intussusception, Nebraska M. J. **18**:121-125 (April) 1933.

HOSPITAL MORTALITY AND SUGGESTIONS FOR DECREASING IT

In this series of cases of acute intussusception, the hospital mortality rate was 23.6 per cent. Surgical shock, superimposed on the toxemia and on the already depleted system of the infant, is the chief factor in the hospital mortality. In 10 of the 13 fatal cases in this series death occurred within a few hours after operation and could be attributed only to those factors. Peritonitis, ileus and pneumonia were contributing factors in the other 3 cases. Of course, early surgical intervention assumes the utmost importance if the child is to be brought to operation in better condition. We feel, however, that more must be done to combat the toxic reaction and refurbish the depleted system before operation is undertaken. It is with that in mind that lately we have been preceding the surgical intervention with a small transfusion of blood, and we have been giving fluids and electrolytes intravenously in the course of the operation to bring the concentrations into the normal range. This transfusion can be taken care of while the operating room is being set up, and if a blood bank and a separate transfusion team are available, it can be completed without any appreciable delay in the operation. Our custom is to use group IV blood (Moss classification) without taking time to type or cross match the blood. There have been no fatal outcomes in the few cases in which this additional treatment has been administered, and we hope that further use of it will materially reduce our mortality rate. Oxygen, too, must be kept in mind as an additional agent of value in our armamentarium.

SUMMARY AND CONCLUSIONS

Fifty-five consecutive cases of acute intussusception which came to operation at the Mayo Clinic are reviewed. The disease is primarily one of infancy and early childhood. The condition attacks otherwise healthy infants, and its ultimate outcome depends a great deal on an early diagnosis followed by prompt surgical intervention. Surgical shock, superimposed on the toxic reaction and the depleted system, is the immediate cause of death in the great majority of fatal cases. Lessening of the mortality rate for this condition seems to depend on earlier diagnosis and treatment supplemented by supportive and replacement therapy before and during the operation.

GIANT INTRACANALICULAR FIBROADENOMA OF THE BREAST

F. M. OWENS JR., M.D.
AND
W. E. ADAMS, M.D.
CHICAGO

A varied and confusing picture is presented by the breast tumor first described by Chelius [1] in 1828 as a "cystic hydatid." Several specimens were described in more detail by Johannes Müller [2] in 1838 under the name of "cystosarcoma phyllodes." The confusion regarding the character and behavior of this interesting tumor is well brought out in the list of names employed in describing the 121 examples which have been reported to date. These various names are as follows:

Cystic hydatid—Chelius [1] 1828
Cellular hydatid—Cooper [3] 1829
Cystosarcoma—Fischer [4] 1835
Cystosarcoma phyllodes—Brunn 1838 (published by Müller [2])
Hydatid tumor of the breast—Warren [5] 1839
Serocystic tumor—Brodie [6] 1846
Cystic sarcoma—Erichsen [7] 1852
Telangiectatic cystosarcoma—Amado [8] 1872
Proliferous cystosarcoma—Gross [9] 1874

From the Department of Surgery of the University of Chicago.

This work was conducted in part under a grant from the Douglas Smith Foundation for Medical Research of the University of Chicago.

1. Chelius: Telangiektasie, Heidelb. klin. Ann. **4**:449, 1828.

2. Müller, J.: Ueber den feinern Bau und die Formen der krankhaften Geschwülste, Berlin, G. Reimer, 1838.

3. Cooper, A. P.: Illustrations of Diseases of the Breast, London, Longman, Rees & Co., 1829, p. 32.

4. Fischer: Cystosarkom der rechten Mamma; Extirpation; Heilung, Ztschr. f. Wundärzte u. Geburtsh. **33**:223, 1882.

5. Warren, J. C.: Surgical Observations on Tumours, London, J. Churchill, 1839.

6. Brodie, B. C.: Lectures on Various Subjects in Pathology and Surgery, London, Longman [and others], 1846, p. 148.

7. Erichsen: Recurrence of Cystic Sarcoma of Breast, Lancet **1**:120, 1852.

8. Amado, S.: Un caso de kisto-sarcoma telangiectasico e papillar da glandula mamaria do homem, J. Soc. d. sc. med. de Lisboa **36**:56, 1872.

9. Gross, S. W.: Proliferous Cysto-Sarcoma of the Breast, Tr. Path. Soc. Philadelphia **4**:216, 1874.

Intracanalicular papillary fibromyxoma—Bigelow[10] 1876
Intracanalicular sarcoma—Iverson[11] 1877
Intracanalicular myxofibroma—Watson[12] 1878
Intracanalicular papillary fibromyxoma—Watson[12] 1878
Sarcoma with lacunar cysts—Raingeard[13] 1882
Intracanalicular myxoma—Jüngst[14] 1884
Proliferating cystic tumor—Leser[15] 1888
Cystosarcoma—Schmidt[16] 1889
Cystosarcoma mammae proliferum—Noetzel[17] 1892
Papilloma intracanaliculare—Kursteiner[18] 1894
Intracanalicular fibroma—Pearce[19] 1895
Intracystic mammary sarcoma—Snow[20] 1899
Cystofibrosarcoma—Grohé[21] 1900
Pearly cystosarcoma phyllodes—Beneke[22] 1902
Ademona pseudosarcomatodes—Beneke[22] 1902
Fibroadenoda intracanaliculare papillare—Schmuckert[23] 1904
Adenomyxofibroma intracanaliculare papillare—Gorham[24] 1911
Fibrolipoadenoma intracanaliculare sarcomatodes xanthomatodes mammae—Binckert[25] 1924

---

10. Bigelow: Tumor of the Breast: Intra-Canalicular Papillary Fibromyxoma, Boston M. & S. J. **94**:581, 1876.
11. Iverson, A.: Cysto-sarcoma mammæ, amputatio mammæ, Hospitalstid. **4**: 331, 1877.
12. Watson, A.: Ueber das Fibro-Adenom der Mamma, Inaug. Dissert., Göttingen, W. F. Kaestner, 1878.
13. Raingeard: Tumeur du sein, Bull. Soc. anat. de Nantes **6**:39, 1882.
14. Jüngst, C.: Ein intracanaliculäris Myxom der Mamma mit hyaliner Degeneration, Virchows Arch. f. path. Anat. **95**:195, 1884.
15. Leser, E.: Beiträge zur pathologischen Anatomie der Geschwülste der Brustdrüse, Beitr. z. path. Anat. u. z. allg. Path. **2**:379, 1888.
16. Schmidt, G. B.: Die Geschwülste der Brustdrüse, Beitr. z. klin. Chir. **4**:78, 1889.
17. Noetzel, W.: Ein Beitrag zur Kenntnis der Fibroadenome der weiblichen Brustdrüse, Inaug. Dissert., Berlin, G. Schade, 1892.
18. Kursteiner, W.: Adenoma der Milchdrüse mit cylindrischem und geschichtetem zum Theil verhorntem Epithel, Virchows Arch. f. path. Anat. **95**:195, 1884.
19. Pearce, F. L.: Further Report on Intercanalicular Fibroma of Right Mammary Gland, Tr. Path. Soc. Philadelphia **17**:157, 1895.
20. Snow, H.: Large Intra-Cystic Mammary Sarcoma Removed by Operation, Brit. Gynaec. J. **15**:157, 1899.
21. Grohé, B.: Ueber Cystofibrosarkome der Mamma mit epidermoidaler Metaplasie, Deutsche Ztschr. f. Chir. **55**:67, 1900.
22. Beneke: Ueber die Adenofibrome der Mamma, Verhandl. d. deutsch. path. Gesellsch. **4**:205, 1902.
23. Schmuckert, K.: Adenofibroma der Mamma übergehend in Adenosarcoma, Munich, C. Wolf & Son, 1904, p. 24.
24. Gorham, W.: Adeno-Myxofibroma papillare intracanaliculare mammae mit Sarkom und Epidermiscysten, Strassb. med. Ztg. **8**:121, 1911.
25. Binckert, M.: Fibrolipoadenoma intracanaliculare sarcomatodes xanthomatodes mammae, Frankfurt. Ztschr. f. Path. **30**:498, 1924.

Giant intracanalicular myxoma—Lee and Pack [26] 1931
Giant intracanalicular fibroadenomyxoma—Smith [27] 1935
Intracanalicular fibroadenoma—Mackenzie [28] 1935

In 1931 Lee and Pack [26] published an excellent and exhaustive review of the literature on this tumor. They collected 105 cases and added 4 cases from their own clinical material. They suggested that the term "giant intracanalicular myxoma" should be adopted.

Since Lee and Pack's review, at least 12 similar cases have been reported, although still with the same confusion of nomenclature. One of 7 cases reported as instances of sarcoma of the breast by Schreiner and Thibaudeau [29] in 1932 almost certainly was a case of the tumor in question. The patient was a woman of 78 years. For eight years she had noted gradual growth of a small tumor of the breast until it reached tremendous size. This tumor, removed by simple excision, measured 63 by 30 cm. and weighed 16 pounds (7.3 Kg.). The patient was well and showed no evidence of recurrence five months later. The description of the tumor was as follows:

> On gross section of the breast, a dense white fibrous growth, in places attached to the skin surface, was disclosed. This tumor showed a glistening gelatinous surface and in places the substance is translucent. Some haemorrhagic areas were found scattered throughout the tumor and a few cysts filled with thin, stringy, gelatinous fluid. Microscopical sections showed a connective-tissue tumor made up of fibrous connective-tissue cells of embryonic type with, in many places, large areas where myxomatous changes had occurred. Some areas of necrosis are found scattered throughout the section. Marked proliferation of the smaller blood-vessels was a rather general occurrence throughout the tumor with some areas of haemorrhagic deposit. In some fields the tumor has become more cellular with the presence of many spindle-shaped cells. Diagnosis.—Myxofibrosarcoma.

The description and the illustrations fit nicely into the category of cystosarcoma phyllodes, and one is led to wonder if this may not be such a tumor.

In 1935 Smith [27] reported 2 cases. One patient was a woman of 44 years who had noted a small lump in her breast for ten years. No change of size had been noted until six months prior to her operation, when there was sudden and rapid enlargement of the mass to the "size of a large orange." The tumor showed typical gross and histologic characteristics.

---

26. Lee, B. J., and Pack, G. T.: Giant Intracanalicular Fibroadenomyxoma of Breast: The So-Called Cystosarcoma Phyllodes Mammae of Johannes Müller, Am. J. Cancer **15**:2583, 1931; Ann. Surg. **93**:250, 1931.

27. Smith, I. H.: Giant Intracanalicular Fibroadenomyxoma of the Breast, Am. J. Surg. **30**:545, 1935.

28. Mackenzie, K.: Huge Fibro-Adenoma of the Breast, Brit. J. Surg. **23**: 234, 1935.

29. Schreiner, B. V., and Thibaudeau, A. A.: Sarcoma of the Breast, Ann. Surg. **95**:433, 1932.

The second patient was a woman of 30 years who had noticed a lump for three years. During the twelve months prior to admission the tumor had grown rapidly to a mass measuring 8 cm. in diameter. This mass also was pathologically typical for the group of tumors here discussed.

Mackenzie [28] reported in 1935 a patient of 34 years who had noticed a rapid increase of size in a small breast nodule, which when removed was found to weigh 35 pounds (15.9 Kg.). The tumor was called an intracanalicular fibroadenoma. There was no recurrence after simple mastectomy.

In a discussion of sarcoma of the female breast in 1935, Rose [30] reported 2 cases of "cystosarcoma" of the breast. One of the tumors was in a woman of 33 years. She had noted a small lump in the breast for two years, but in the month prior to her operation the mass had suddenly grown rapidly to tremendous size. The other patient, a woman of 28 years, had noted a small sessile mass in the breast for one year. In four months it had reached massive proportions and had ulcerated. Both were cured by excision. The microscopic features of the tumors were typical.

In 1936 Markowitz and Howell [31] reported a tumor of this sort in a 14 year old girl. In two months the breast had enlarged to twice normal size and contained a mass measuring 11 by 14 cm. Simple excision effected a cure.

In 1938 Funck-Brentano and associates [32] reported 5 cases. The average age of the patients was 38.7 years, and all gave a history of a small sessile mass in the breast quiescent for variable periods which then suddenly grew to alarming proportions in a period of about a year. One gave a history of gradual growth for five years, another a history of rapid growth for fifteen days, while the rest reported rapid growth over a period of eight or nine months. These tumors had all of the gross and microscopic characteristics of the "giant intracanalicular myxoma."

Under the name "giant intracanalicular fibroadenomyxoma" a case of the tumor in question was reported by Desaive [33] in 1939. The patient, a single woman of 44 years, had been aware of a small hard tumor in her breast for eighteen years. She injured the breast in an accident in 1935, and after this there began a slow enlargement of the breast. The progres-

30. Rose: Die Sarkome der weiblichen und die Geschwülste der männlichen Brustdrüsen nach dem Material der chirurgischen Klinik zu Leipzig, Deutsche Ztschr. f. Chir. **246**:151, 1935.

31. Markowitz, B., and Howell, H. L.: Rapid Growth of a Large Breast Fibroma in a Young Girl, J. A. M. A. **107**:1043 (Sept. 26) 1936.

32. Funck-Brentano, P.; Bertrand, I., and Poilleux, F.: Les tumeurs phyllodes du sein. (Cysto-sarcoma phyllodes de Johann Müller), J. de chir. **51**:506, 1938.

33. Desaive, P.: Le fibro-adéno-myxome intracanaliculaire géant du sein, type phyllode de Johann Müller, Ann. Soc. méd.-chir. de Liége, 1938, pp. 239-248.

sion of the lesion continued until it ulcerated and herniated in 1938. The breast was removed at that time; the tumor mass weighed 4.9 Kg. The gross and microscopic appearance of the tumor was typical, and the patient was free from any recurrence six months later.

A review of the main features described brings out certain developmental and morphologic peculiarities of this tumor. The clinical history of the condition may simulate that of sarcoma of the breast in that there is rapid growth of a mass in the breast to a large size. However, in almost every case there will be a history of a preexisting mass in the breast. This remains quiescent for a number of years, then rapidly enlarges and grows to alarming proportions. Some of these tumors weigh as much as 20 Kg., and the average weight of the reported ones is 7.6 Kg.

Enlargement may progress to such proportions that rupture of the skin occurs with herniation of cauliflower-like masses through the opening. Pain is not a prominent symptom, and the only complaints are apt to be the size of the breast or the disability resulting therefrom. Sarcomatous degeneration with metastasis has been known to occur. However, simple amputation of the breast mass is ordinarily successful in effecting a cure, although there may be local recurrence.

The tumor warrants pathologic study because of its resemblance to and confusion with sarcoma. Externally the breast is bosselated with variable regions of fluctuation and resistance. When the breast is cut, the tumor is found to consist of huge, well encapsulated intracystic polypoid masses with narrow tortuous clefts, which contain thin fluid ranging in color from yellow to brown. As enlargement progresses, the polypoid masses tend to become flattened and may completely fill the cystic spaces, so that the tumor appears solid. The cut surfaces show great variation, having degenerating zones alternating with areas of solid tissue. Scattered throughout and constituting the majority of the solid parts of the tumor is a soft semitransparent tissue. There is a strong limiting capsule about the tumor, and no invasion of the surrounding tissues occurs.

Histologically the tumor shows variation closely paralleling the gross appearance. The close structural resemblance of the entire tumor to intracanalicular fibroadenoma is striking. Buds of connective tissue project for varying distances into spaces which are slitlike in character, and none of these numerous slitlike spaces is without epithelial lining. Polymorphism of the stroma is remarkable. Sclerotic plaques composed of cellular areas with dense masses of collagen are scattered among myxoma-like regions or areas of edematous infiltration. No bone or cartilage is present. The amount of necrosis and hemorrhage varies in direct proportion to the size of the tumor.

REPORT OF A CASE

Mrs. G. K., the patient, was 37 years old, white, mulliparous and married. The family and personal history were irrelevant, save for the complaint of disturbances associated with her menses. Menstruation began at 13 years with periods at intervals of thirty days, lasting five to six days. However, she always suffered severe dysmenorrhea with nausea and vomiting on the second day, and for three or four months had noted some bleeding between periods. Her last menstrual period was two weeks before admission on July 10, 1940.

At this time she had known of a mass in her left breast since July 1939. This had appeared in the inferolateral quadrant of the breast, was hard, circumscribed and covered with tense skin. During the summer of 1939 the mass gradually enlarged, and the entire breast then became swollen and tender. Tenderness was most marked just preceding the menstrual period. No discharge from the nipple

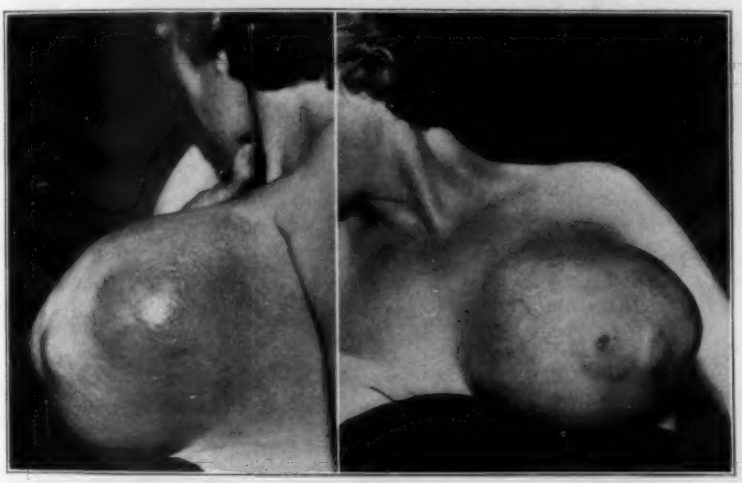


Fig. 1.—Two views showing the appearance of the breast on admission.

and no dimpling of the skin were noted. In the winter of 1939-1940 the patient noted that the breast was rapidly enlarging, so that it became twice the size of the right breast. She also noted two reddened areas in the skin about 3 to 4 cm. in diameter. These rapidly became blue, and the entire breast became hot and more tender, while the skin over the breast became tightly stretched. About a month later the breast suddenly softened and became smaller. During the spring of 1940 the mass changed little and bothered the patient only slightly. Two days prior to entry the patient had a chill and became ill with "flu." Within thirty-six hours the breast had grown to twice its size of the previous several months. It became tense, reddened and then turned dark grayish blue. She had suffered no loss of weight, but on the contrary had gained 8 pounds (3.6 Kg.) in the preceding seven months.

On admission the patient appeared acutely ill and was febrile (temperature, 101 F.); her pharynx and larynx were congested. The left breast, swollen to four times the size of the right, was tense and tender. The lateral surface was reddened and hot, and the inflammation extended around to the posterior axillary

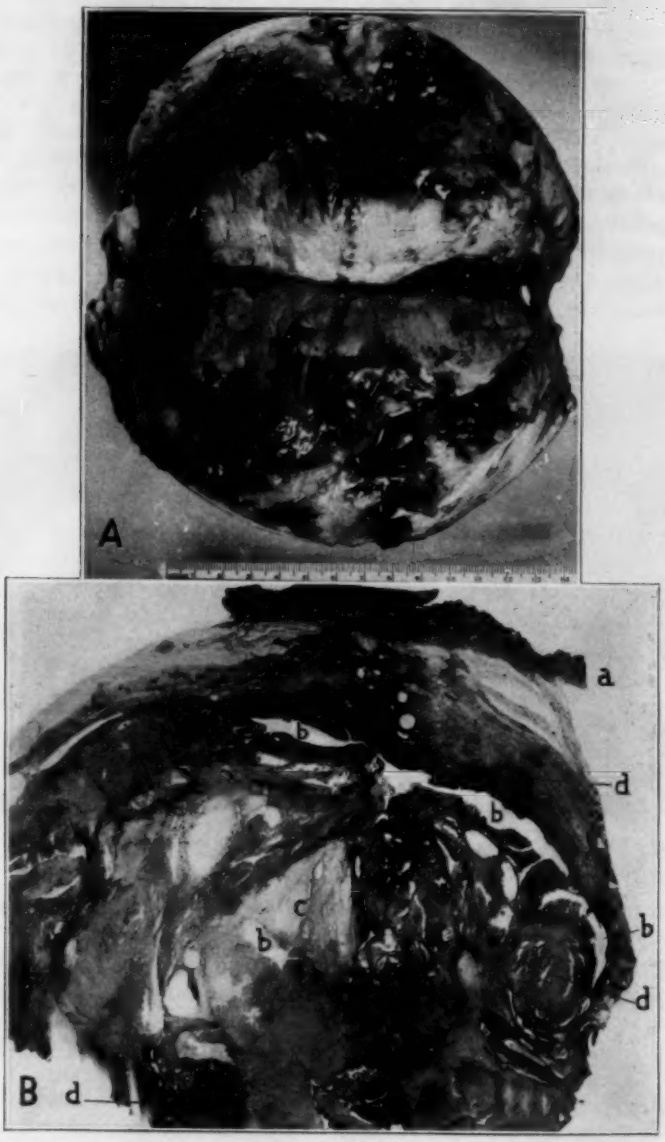


Fig. 2.—*A*, photograph of the gross specimen divided in half. Note the irregular cleftlike spaces which contained thin yellowish fluid. *B*, low power magnification of a microscopic section taken through most of the tumor mass. Note (*a*) skin overlying the tumor, (*b*) irregularly sized and shaped spaces, (*c*) partially necrotic and markedly edematous connective tissue and (*d*) widely scattered nests of gland elements.

line. The entire breast appeared fluctuant, and there were several intensely red areas in which the skin was shiny, thin and stretched taut. Just below the normal areola was a slightly elevated bluish area which transluminated and felt fluctuant.

With the diagnosis of acute abscess of the breast, a 4 cm. radial incision was made in the upper outer quadrant of the breast in the region of maximum fluctuation. A large cyst containing about 100 cc. of a yellowish brown turbid serous material was broken into. The entire breast seemed to be composed of a grayish friable tissue honeycombed with cystic areas containing a turbid serous material.

Microscopic examination of fragments of the tissue led to a diagnosis of cystosarcoma phyllodes. Cultures of the fluid from the cystic cavity were sterile.

Seventeen days later, after the subsidence of the acute infection of the upper respiratory tract, a simple mastectomy was performed. A few of the superficial fibers of the pectoralis major muscle were removed with the breast. The gross specimen weighed 2,650 Gm. and measured 9 by 15 by 20 cm. A central round firm mass with small fluctuant areas occupied the major portion of the breast (except for about 1 to 2 cm. around the periphery). The ellipse of skin excised with the mass included the areola and the nipple. The skin was of normal texture and was not fixed to the tumor; the nipple was not inverted. Also, the tumor was not adherent to the resected portion of the pectoral muscle.

A cut surface of the mass showed many cystic spaces from a few millimeters in diameter to a large cyst, 3 cm. in diameter, which communicated with the surgical drainage wound. The cysts were filled with a slightly turbid brownish yellow fluid. Much of the stroma of the tumor appeared translucent, and from these areas fluid escaped when a fresh cut was made. The main tumor mass was well demarcated peripherally and was surrounded by a firm fibrous capsule which could be separated with ease from the mass. The outer parts of the tumor appeared yellowish white and seemed to be made up of strands radiating out from the central portion.

In spite of slight secondary infection of the operative wound, healing was rapid and entirely satisfactory. Eight months subsequent to her operation the patient was quite well, and there was no sign of any recurrence.

In sections from different portions of the tumor mass the gland spaces varied from closely grouped small acini to large cystic spaces. There was a corresponding variability of epithelial linings. In some acini the epithelium was a single-layered cuboidal epithelium, while in still other areas the cells were cuboid but piled up in several layers. A great deal of desquamation of epithelial cells into the glandular lumens was evident. Many of the larger spaces were lined by a single layer of flattened cells. Immediately beneath the epithelium of the gland spaces was a single layer of large clear cells with rather large round nuclei. Much of the stroma of the breast was made up of dense sheets of hyperchromatic spindle-shaped cells. These cells were arranged in streams in a fairly orderly fashion between the glandular structures. Many club-shaped projections of cellular stroma covered by epithelium projected into gland spaces, converting them into slitlike cavities. In these cellular areas the nuclei of the spindle-shaped cells were small and dark staining, while in the less cellular, myxoma-like areas the nuclei were pale and contained a dark nucleolus in a thin network of chromatin. In the latter regions many of the cells contained large vacuoles, and there were spaces containing no stainable material separating the collagen fibers and cells. Capillaries lay scattered throughout the dense cellular areas in moderate numbers, but relatively few could be found in the myxoma-like regions. Mallory stains revealed that the collagen was most dense and arranged more truly in fibers in

the regions containing the spindle-shaped cells with small hyperchromatic nuclei. In the myxoma-like areas the collagen bundles were swollen and less abundant. No mitotic figures were present in any of the various regions. Numerous areas

Fig. 3.—Low power magnification of a microscopic section showing the intracanalicular character of the growth; × 25.

of hemorrhage and necrosis were scattered throughout the tumor, but the only evidence of inflammatory reaction was found in those portions of the mass adjacent to the site of the first operation.

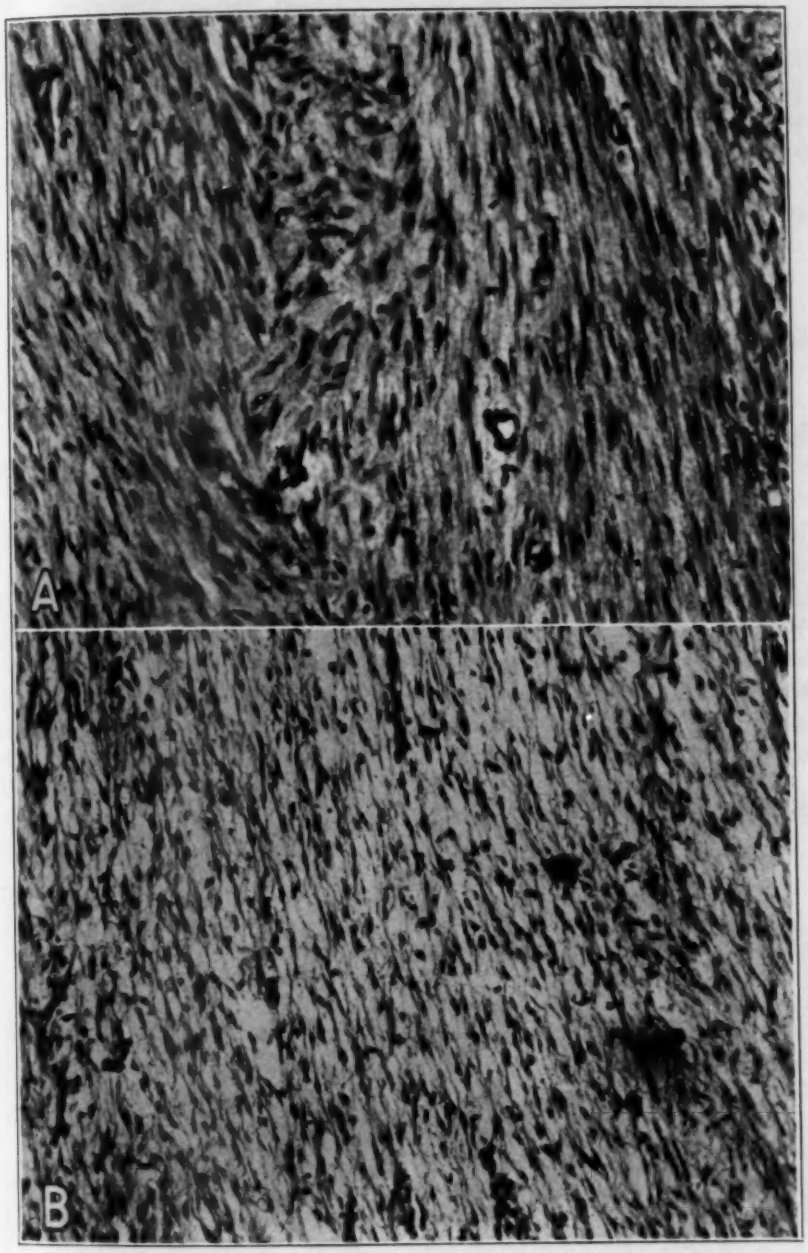


Fig. 4.—*A*, high power magnification of section from the dense cellular zone; × 250. *B*, section from the edematous area; × 140.

COMMENT

The confusion regarding the character of this peculiar mammary tumor is obvious both from the multiplicity of names it has received and from the variations in histologic structure. The extreme cellularity of parts of the tumor suggests a sarcoma. However, the cell-rich stroma is of a benign type, and while sarcomatous degeneration may occasionally result, this is essentially a benign neoplasm. The myxoma-like character of large portions of the stroma has led many observers to classify this tumor as a myxoma or myxofibroma. However, similar areas are often seen in other fibromatous tumors, such as the fibroids of the uterus and the ordinary fibroadenomas of the breast. It seems more likely, as Ochsner [34] emphasized, that these "myxomas" merely represent regions of marked edema. Since the general structure is essentially that of an intracanalicular fibroadenoma of the breast, the most fitting name for this tumor would seem to be "giant intracanalicular fibroadenoma of the breast."

SUMMARY

A brief review of the history of the breast tumor commonly known as "cystosarcoma phyllodes" is presented, and its gross and microscopic features are detailed. The 121 cases reported since 1931 are summarized, and our own case is presented. With the 109 cases discussed by Lee and Pack in 1931, the total reaches 122 cases. A list of the various names applied to the tumor is given. Because of the multiplicity of terms used for this pathologic entity, a plea is made for the acceptance of the simple descriptive term, "giant intracanalicular fibroadenoma of the breast."

34. Ochsner, A. J.: Surgical Diagnosis and Treatment, Philadelphia, Lea & Febiger, 1920, vol. 2, p. 167.

ADENOCARCINOMA OF TONGUE ARISING FROM VESTIGE OF MEDIAN ANLAGE OF THYROID GLAND

REPORT OF A CASE

WILLIAM J. CROMARTIE, M.D.
AND
OSCAR G. NELSON, M.D.
NASHVILLE, TENN.

The origin of the median anlage of the thyroid gland as a diverticulum from the mesobranchial region of the pharyngeal floor, which lies between the ventral extremities of the first two gill pouches, was conclusively demonstrated by Norris [1] in a study of human embryos. According to Joll,[2] maldevelopment of the median anlage is known to give rise to a variety of abnormalities, which may be located in the midline from the foramen caecum to the level of the suprasternal notch. They include solid tumors, cysts, sinuses and fistulas. A solid tumor of the thyroglossal tract is most common in the region of the foramen caecum, although microscopic amounts of thyroid tissue may occur in any part of the primitive tract. Such a tumor usually consists of well differentiated thyroid tissue and constitutes a lingual thyroid. Ray [3] collected 250 cases of this condition recorded in the literature from 1866 to 1938. In the majority of instances in which histologic study was made the structure of this aberrant tissue was similar to that of the normal gland. In a small percentage the fetal pattern of thyroid tissue was found. Cystic changes were not uncommon, being especially prominent in large lingual glands in cretins.

Malignant tumors of the tongue, whose histogenesis seems to represent an abnormal development of the median anlage of the thyroid gland, have been reported. Ray,[4] in 1918, recorded the case of a man 74

From the Department of Pathology, Vanderbilt University School of Medicine, and from the Protestant Hospital.

1. Norris, E. H.: The Early Morphogenesis of the Human Thyroid Gland, Am. J. Anat. **20**:411, 1918.

2. Joll, C. A.: Diseases of the Thyroid Gland, London, William Heinemann, 1932, p. 124.

3. Ray, B. S.: Lingual Thyroid, Arch. Surg. **37**:316 (Aug.) 1933.

4. Ray, H. M.: Carcinomatous Transformation of a Lingual Goiter, Proc. New York Path. Soc. **18**:12, 1918.

years of age who complained of a gradually enlarging tumor of the tongue which had been present for three years. He had lost 70 pounds (32 Kg.) of weight and was markedly emaciated. On the left side of the tongue there was a "lemon-sized" tumor; this was enucleated, and the patient died two days later of bronchopneumonia. Gross examination of the surgical specimen showed an encapsulated, spherical mass, 5 cm. in diameter. Histologic study revealed that the tumor consisted chiefly of acini of varied size and configuration. These were separated by scanty connective tissue and lined by epithelium of both cuboidal and high columnar type. Papillary projections were noted in some of the acini. "The basement membrane in some areas was not intact and there were definite indications of carcinomatous transformation." A hemorrhagic exudate was found in some of the acini and homogeneous pinkish-staining material in others. A diagnosis of carcinomatous transformation of a lingual goiter was made.

The case reported by Tyler [5] in 1923 was that of a man who noticed a nodule on the base of the tongue twelve years before death. During the last two years of life he was treated with roentgen rays and radium. A biopsy of the nodule showed thyroid tissue with hyperplasia. At autopsy an ulcerated lesion, 3 cm. in diameter, involving the posterior half of the tongue was seen. Multiple nodules, 1 mm. to 10 cm. in diameter, were found throughout the lungs. There were enlarged lymph nodes along the spine and in the mediastinum. No microscopic studies of the nodules in the lungs or of the lymph nodes were made. The only histologic section described was that from the tongue and consisted of hyperplastic thyroid tissue. A diagnosis of aberrant thyroid gland in the root of the tongue with malignant degeneration was made.

Ashurst and White,[6] in 1925, recorded the case of a white man 56 years of age who had had a nodule on the base of the tongue for more than twenty years. Seven years after its first appearance the nodule was excised. The mass gradually returned, and the development of the nodules in the neck was noted. Difficulty in swallowing and pain in the tongue also developed. The mass was 8 cm. long and was elevated about 2.5 cm. above the surface of the right side of the posterior half of the tongue. The lymph nodes of the neck were enlarged markedly, and there was moderate enlargement of the epitrochlear, femoral, inguinal and iliac lymph nodes bilaterally. The tumor was partially excised. After this the cervical nodes decreased in size. The patient was observed for several months and continued to do well. Microscopic sections of

5. Tyler, A. F.: Carcinoma of Lingual Thyroid with Metastasis in Lungs, J. Radiol. **4**:381, 1923.

6. Ashurst, A. P. C., and White, C. Y.: Carcinoma in Aberrant Thyroid at Base of Tongue, J. A. M. A. **85**:1219 (Oct. 17) 1925.

the tumor showed areas of typical thyroid tissue. In other areas anaplastic features consisting of cords and alveolar arrangements of the cells were present. In some areas there was little stroma, while in others dense masses of fibrous tissue separating small nests of cells were seen. A diagnosis of adenocarcinoma of the lingual thyroid was made. No microscopic studies of the enlarged lymph nodes were reported.

Levi and Hankins [7] in 1935 reported a case of carcinoma of the lingual thyroid occurring in a 21 year old white woman who five days previous to examination had noticed a tumor mass at the base of the tongue. In the region of the foramen caecum a reddish brown mass of firm consistency, measuring 2 by 2 by 1.5 cm., was found. It was attached to the musculature of the tongue by a broad base. The tumor was widely excised. Three months later signs of myxedema developed with a basal metabolic rate of —130 per cent. Nine months after operation no evidence of recurrence of the growth had appeared. Microscopic sections showed highly irregular and poorly formed acini of the thyroid type with occasional small amounts of colloid in their lumens. The acinar cells were large, ovoid and spherical, often deeply staining, with occasional poorly formed mitotic figures. The fibrous capsule and the musculature of the tongue were extensively invaded by neoplastic cells. A diagnosis of low grade carcinoma occurring in the thyroid tissue was made.

In 1935 Marchal, Soulié, Grupper and Roy [8] reported the case of a white man aged 59 who had a hemorrhagic cauliflower-like tumor at the right lateral border of the posterior portion of the tongue and enlargement of the submaxillary lymph nodes. After the removal of the tumor a mass developed in the right biceps muscle. Two years after removal of the tumor of the muscle it recurred. At this time signs of congestive heart failure developed, and the patient died. Autopsy revealed that the tumor of the tongue had recurred and that the cervical lymph nodes were enlarged. A hemothorax was present on the right, and the right pleural surfaces were covered with tumor nodules. A mass of tumor was found replacing the superior pole of the right kidney. The tumor in the right biceps muscle was associated with an arteriovenous aneurysm of the right brachial artery and vein. Microscopic study of all the tumor nodules showed a similar picture. They consisted of acini of varying sizes, some of which were filled with colloid. In other areas the cells were arranged in cords and had a pleomorphic appearance. A few mitotic figures were seen. Definite infiltration of the muscle of the

7. Levi, L. M., and Hankins, F. D.: Carcinoma of Lingual Thyroid, Am. J. Cancer **23**:328, 1935.

8. Marchal, G.; Soulié, P.; Grupper, C., and Roy, A.: Adénocancer d'un vestige thyroïdien de la lange. Métastases multiples avec anévrisme artério-veineux de l'humérale, Bull. et mém. Soc. méd. d. hôp. de Paris **51**:953, 1935.

tongue was described. A diagnosis of adenocarcinoma of an aberrant thyroid of the tongue was made.

Watson and Pool [9] stated that in 3 of a series of 167 cases of cancer of the thyroid the growth occurred in lingual thyroid tissue. No details of the clinical or pathologic records of these cases is given.

The condition in the following case report seems to belong to this group of infrequent malignant tumors of the tongue which appear to concern an abnormal development of the median anlage of the thyroid gland.

REPORT OF CASE

History.—A. E. C., a 52 year old white woman, a housewife, was admitted to the Protestant Hospital on Jan. 1, 1941. She was in a semicomatose state. Members of her family stated that about four and one-half years previously the patient had noticed a mass on the posterior surface of the tongue which had gradually increased in size and caused difficulty in swallowing. During the previous four years the lesion had been treated with roentgen rays and radium. The treatment had caused a temporary decrease in the size of the mass, and her ability to swallow had improved. During the last few months before admission, however, swallowing had become almost impossible and she lost 30 to 40 pounds (14 to 18 Kg.) in weight. For two weeks before admission the patient had seemed to have fever and had gradually become stuporous. The past history revealed nothing of significance.

Physical Examination.—The patient was markedly emaciated and stuporous and appeared to be about 60 years of age. Other than evidence of marked loss of weight, the important physical findings were limited to the mouth, pharynx, neck and chest. The mucous membranes of the anterior portion of the mouth showed no lesion. On the dorsum of the posterior half of the tongue there was an elevated hard nodular mass that almost completely filled the posterior part of the pharynx. The surface of this mass was irregular and grayish. No ulcerated areas were seen. The skin of the neck was brownish, and all the underlying tissues were of a firm consistency. No definite nodules could be made out in the neck, and the thyroid could not be felt. The breasts were atrophic. The respiratory movements were shallow and rapid. There was dulness over the bases of the lungs posteriorly, and numerous fine and coarse rales were heard over these areas. The heart was not enlarged, and no murmurs were heard. No abnormalities of the abdomen or of the pelvis were found.

Laboratory Data.—The urine was normal. A white blood count of 5,750 was differentially normal. The hemoglobin content was 12.5 Gm. per hundred cubic centimeters.

Course in Hospital.—The temperature rose from 100 to 101.2 F. as the patient gradually passed into complete coma. The blood pressure fell from 128 systolic and 80 diastolic to 50 systolic and 40 diastolic. She was treated with intravenous fluids and with ephedrine but failed to respond; she died eighteen hours after admission.

---

9. Watson, W. L., and Pool, J. L.: Cancer of the Thyroid, Surg., Gynec. & Obst. **70**:1036, 1940.

Postmortem Examination.—Autopsy was performed one hour and forty minutes after death. The skin generally was dry and inelastic, and the skin of the neck was firmly attached to the underlying tissue.

The peritoneal cavity contained no free fluid, and its surfaces were free of exudate. No free fluid was present in the pleural cavities. The pleural surfaces of

Fig. 1.—*A*, the cut surface of two portions of lung tissue showing metastatic tumor tissue. *B*, superior view of the tongue and larynx. C, sagittal section of the tongue and larynx.

the lower lobe and the interlobal fissures of the right lung were covered with a fibrinous exudate. The heart showed no gross lesions. The left lung weighed 460 Gm. and the right lung 600 Gm. The lower lobes and the inferior portion of the upper lobes of the two lungs and the middle lobe of the right lung were generally of a firm consistency. The small bronchi appeared dilated and stood out

distinctly on the cut surface. In each lobe of the right lung and in the lower lobe of the left lung several firm discrete nodules, which measured from 0.5 to 2 cm. in diameter, were found (fig. 1 *A*). On section these nodules consisted of homogeneous grayish white tissue which was mottled in some areas by reddish discolorations. No gross evidence of tumor metastasis was seen in the tracheobronchial lymph nodes.

The gastrointestinal tract, liver, spleen, pancreas, adrenals, kidneys, ureters, bladder and internal genitalia showed no gross lesions.

The organs of the neck, including the tongue, were removed. From the surface of the posterior half of the tongue a grayish white hard lobulated nodule of tissue protruded. The surface of this measured 4 by 2.5 cm. It projected approximately 1.5 cm. above the surface of the tongue. The surface of the mass was not ulcerated. The mass filled the space between the root of the tongue and the epiglottis and displaced the epiglottis posteriorly and inferiorly (fig. 1 *B*). A sagittal section through the tongue and pharynx showed replacement of the posterior half of the genioglossus and geniohyoid muscles and the tissue between the epiglottis and these muscles by tumor tissue (fig. 1 *C*). Extension of the tumor into the tissues inferior and lateral to the tongue could not be made out grossly. The tissue of the pharyngoepiglottic folds and the aryepiglottic folds appeared edematous, and the superior aperture of the larynx was narrowed. An oval superficial erosion of the mucosa, which measured 0.4 by 1 cm., was noted on the first portion of the esophagus. No other lesions of the esophagus were seen. No enlarged cervical lymph nodes were found. The subcutaneous tissue of the anterior and lateral portions of the neck was indurated, apparently from an increase in fibrous tissue. The thyroid gland was small, weighing only 7.5 Gm.

Microscopic Examination.—Blocks of tissue were fixed in Zenker's fluid with 10 per cent acetic acid, and sections were stained with hematoxylin and eosin. Sections of the heart, gastrointestinal tract, liver, spleen, pancreas, kidneys and bladder showed no remarkable microscopic changes.

Sections of the tongue showed no ulceration of the mucous membrane. In some areas the tumor tissue was found adjacent to the mucous membrane, but no definite invasion of the epithelium was seen. The stroma adjacent to the epithelium was filled by monocytes and lymphocytes. Large areas of muscle had been completely replaced by tumor tissue, and in other areas the muscle had been infiltrated by the neoplastic cells. The tumor tissue consisted chiefly of irregularly shaped masses of cells with indistinct cell boundaries. The cytoplasm stained lightly. The nuclei were relatively large and ovoid and contained small scattered masses of chromatin. No mitotic figures were seen. These masses of cells were separated by a loose fibrous tissue stroma. Scattered throughout these groups of cells acini of varying sizes were seen. A few of the acini were lined by a single layer of cuboidal or columnar epithelial cells which showed a uniform polarity. Others were lined by several layers of cells which were irregular in shape. In the lumens of a small proportion of the acini there was a homogeneous pink-staining material. The majority contained pale pink-staining granular material (fig. 2, *A* and *B*).

The metastatic nodules in the lungs presented a microscopic picture similar to that of the tumor of the tongue (fig. 2, *C* and *D*). Evidence of bronchiectasis, micro-

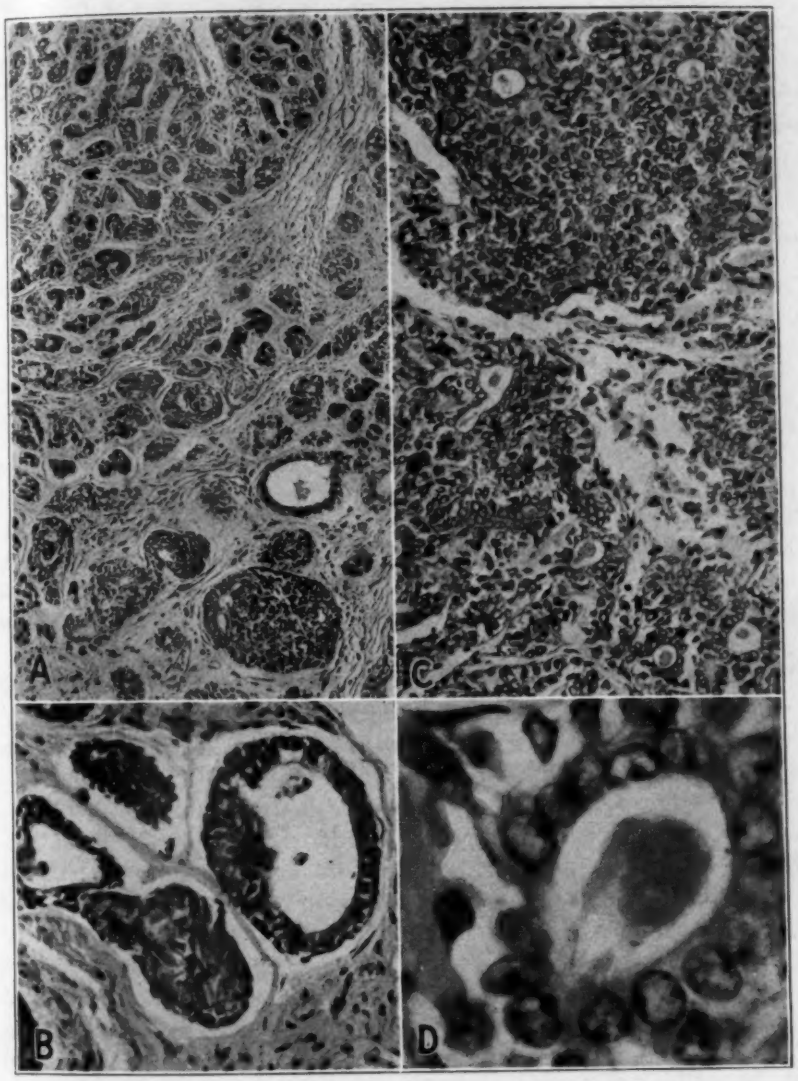


Fig. 2.—Photomicrographs (hematoxylin and eosin stains) showing (*A*, × 100) and (*B*, × 250) tumor of the tongue and (*C*, × 160 and *D*, × 1,160) metastatic tumor of the lung.

scopic abscesses and bronchopneumonia which was undergoing organization was also present in the sections of the lungs.

Sections of the thyroid gland showed large and small acini filled with colloid. The large acini were lined by flat epithelium and the smaller acini by cuboidal epithelium. The acini were widely separated by loose connective tissue, indicating atrophy or hypoplasia of this gland. Sections of the tracheobronchial lymph nodes showed acute and chronic lymphadenitis with no evidence of metastatic neoplastic lesions.

Diagnosis.—A diagnosis of the following conditions was made: adenocarcinoma of the tongue arising from a vestige of the median anlage of the thyroid gland with metastasis to the lungs, bronchiectasis, multiple microscopic abscesses of the lungs, organizing bronchopneumonia and hypoplasia of the thyroid gland.

COMMENT

The primary site of the tumor in the case presented suggested that its origin might represent an abnormal development of the median anlage of the thyroid gland. This idea was supported by the histologic structure of the neoplasm. It did not have the characteristics of an anaplastic carcinoma but appeared to be embryonic glandular tissue. The histologic structure corresponded closely to that of the thyroid tissue found in 50 mm. human embryos (Norris [10]). The fact that embryonic glandular tissue may persist along the thyroglossal tract is illustrated by a case reported by Marshall.[11] In describing the central portion of the thyroglossal tract in his case, he stated: "The whole structure gives the idea of embryonic or imperfectly developed glandular tissue." In the case presented there seemed to be a persistence of embryonic glandular tissue in the region of the foramen caecum in which malignant neoplastic qualities developed while the histologic structure of embryonic glandular tissue was maintained. The malignant qualities were evidenced by invasion of the musculature of the tongue and by the metastatic lesions in the lungs. No well differentiated thyroid tissue was found in the tongue. This neoplasm did not appear to represent a carcinoma of a lingual thyroid but seemed to have its origin in a vestige of the median anlage of the thyroid which had not differentiated to the adult type of thyroid tissue.

The infrequency of carcinoma of the tongue which arises either from lingual thyroid or from an undifferentiated vestige of the median anlage of the thyroid gland is indicated by the few cases which have been recorded in the literature. In some of these cases inadequate evidence is presented to support the diagnosis made. In Tyler's report [8] the only

10. Norris, E. H.: The Marsogenesis of the Follicles in the Human Thyroid Gland, Am. J. Anat. **20**:411, 1916.

11. Marshall, C. F.: The Thyro-Glossal Duct or Canal of His, J. Anat. & Physiol. **26**:94, 1891.

microscopic sections described were from the tongue and showed hyperplastic thyroid tissue. No morphologic evidence that the tumor of the tongue was malignant or that the lesions in the lungs and lymph nodes represented metastatic tumor tissue from the tongue was presented. In Ray's case [4] the diagnosis of a carcinomatous transformation of a lingual goiter was made. Grossly the tumor removed from the tongue was encapsulated. Microscopically the tumor seemed to consist chiefly of thyroid tissue which was hyperplastic, as evidenced by the papillary projection of epithelium into the acini. He stated that "the basement membrane in some areas was not intact and there were definite indications of carcinomatous transformation." He did not elaborate further on the evidence of malignancy. No invasion of the musculature of the tongue was described, and no metastatic lesions were demonstrated.

In the case reported by Ashurst and White [6] the portion of the tumor studied microscopically was that which projected above the surface of the tongue; this showed typical thyroid tissue in areas. "In certain areas of the section, running from typical lobules of thyroid tissue, were dense accumulations of epithelial cells, placed in bands or cords; and in still other areas there was a tendency to alveolar arrangement, that is, an arrangement typical of adenocarcinoma. . . . In other parts this carcinomatous arrangement was marked by increase of fibrous tissue, separating the epithelial cells into distinct cancer nests, with somewhat the appearance of scirrhous carcinoma." No definite evidence of local invasion or of metastasis was described. The presence of epithelial cells in thyroid tissue arranged in bands and in alveolar form is not conclusive evidence of malignancy. Levi and Hankins [7] presented decisive evidence to support their diagnosis of carcinoma of lingual thyroid in their case. The development of the clinical picture of myxedema in the patient three months after operation indicates that the tumor was a lingual thyroid. The microscopic evidence of malignancy, including invasion of the capsule and of the musculature of the tongue by anaplastic tumor tissue, seems to be conclusive.

The microscopic structure and the multiple metastases confirmed the diagnosis of an adenocarcinoma of a thyroid vestige of the tongue in the case reported by Marchal, Soulié, Grupper and Roy.[8] There was well differentiated thyroid tissue present in the tongue, as well as the anaplastic malignant tissue.

The lesion in the case we have described seems to be this kind of tumor in that it is an adenocarcinoma of the tongue that arises from a vestige of the median anlage of the thyroid gland. It differs from the growths in the other reported cases in that the vestige of tissue had not differentiated into the adult type of thyroid tissue but had remained embryonic in structure.

Conclusions cannot be drawn as to the natural history of this group of neoplasms from the few cases which have been reported. Apparently the possibility of malignancy should be considered in a patient presenting a tumor in the region of the foramen caecum. There is some evidence that surgical excision is the treatment of choice.

SUMMARY

1. A case of adenocarcinoma of the tongue whose histogenesis seemed to concern the persistence of a vestige of the median anlage of the thyroid gland is reported.

2. In this case the vestige of tissue maintained its embryonic structure, invaded the musculature of the tongue and metastasized to the lungs.

3. Other cases of adenocarcinoma of the base of the tongue in which the origin seemed to concern an abnormal development of the median anlage of the thyroid gland are reviewed.

CREMASTERIC SPASM

M. MUSCHAT, M.D.

Urologist to the Mount Sinai Hospital and Research Associate in Urologic Surgery, University of Pennsylvania School of Medicine

PHILADELPHIA

The cremaster muscle, originating from the lower fibers of the obliquus internus and transversalis muscles of the abdomen, runs along the spermatic cord and then spreads fanwise downward within the cremasteric fascia to envelop the testis and adnexa. The size of these muscle strands varies from 20 to 200 microns in the normal person. The response of the cremaster to stimuli is the same as that of any other striated muscle. It is lowered in atrophy and increased in hypertrophy.

I encountered a case of bilateral hypertrophy of the cremaster muscle with spasticity, causing painful contractions and thus disrupting the patient's daily work. These painful spasms finally became unbearable, and the patient was forced to seek relief through operation.

REPORT OF A CASE

C. R., a white man 24 years of age, was referred by Dr. N. Pastor to the Mount Sinai Hospital and admitted Nov. 7, 1940. His occupation was that of a shipper. His chief complaint was, "The inside of the scrotum swells up tight." This condition started about three months previously. While working at his job, without apparent reason, he would suddenly feel both testes pulling upward in a painful spastic contraction and remaining high, held in place by a tense scrotum pressed tightly against the pubic bone (fig. 1). He would then stop working, as any movement would aggravate the painful spasm. He had to lie down and rest until the spasm wore off. Lately, these spasms had begun to occur more frequently. He had lost 9 pounds (4 Kg.) in three months, worrying over his condition. He had always been in good health and had had no operations. His sexual history was normal until three months before admission, and then each attempt would bring on painful spasms.

Physical examination disclosed nothing to account for his symptoms. The internal and external genitalia were normal. The cremaster reflex was hyperactive on both sides. The spasm could not be brought on by local irritation. The blood and urine were normal.

Operation.—On November 7, under low spinal anesthesia, a bilateral operation on the scrotum was performed. An incision was made in the upper part of the scrotum down to the cremasteric fascia. The spermatic cord and testis were lifted out of the scrotum by blunt stripping. The muscle bundles of the cremaster were distinctly overdeveloped with heavy strands of cremaster muscle running fanwise over the fascia downward. It was noted that the slightest pinch with the forceps would cause a contraction with a resulting upward pull of the testis. The

cremasteric fascia was then incised all around the spermatic cord and stripped clean off the cord and testis. Thus the entire cremasteric fascia was removed. The testis was then replaced in the scrotum, and the skin was closed with clips around a small piece of rubber dam drainage. The same findings were noted, and the same procedure was carried out on the opposite side.

Pathologic Observations.—Two pieces of cremasteric fascia, measuring 9 by 1 cm. and 7 by 5 cm., respectively, were removed. They appeared normal except for tremendous hypertrophy of the cremasteric muscle bundles (fig. 2).

LITERATURE

Reviewing the literature, one finds only a few reports of similar cases (Mitchell,[1] Hamburger,[2] Cornil and Mosinger,[3] Zucarelli,[4] Talmud,[5] Haberland,[6] Thomas,[7] Kovalevsky[8] and McDonald and Mayo[9]).

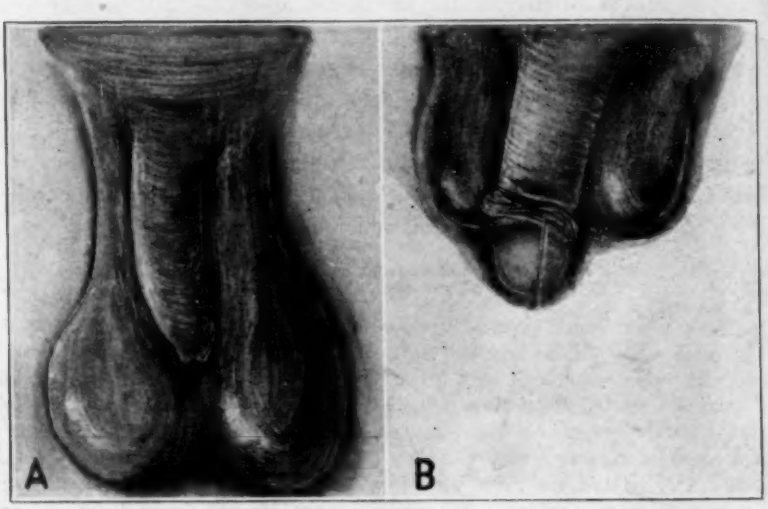


Fig. 1.—*A*, position of testes at rest; *B*, during spasm. Note upward and inward pull.

CAUSATION

The explanation of the cremasteric spasm is still obscure. Two theories have been advanced. One group of authors expressed the

1. Mitchell, S. W.: J. Nerv. & Ment. Dis. **4**:577, 1879.
2. Hamburger, F.: München. med. Wchnschr. **66**:461, 1919.
3. Cornil, L., and Mosinger, M.: Paris méd. **2**:308, 1930.
4. Zucarelli, P., cited by Cornil and Mosinger.[3]
5. Talmud, J. L.: Ztschr. f. d. ges. Neurol. u. Psychiat. **118**:414, 1929.
6. Haberland, H. F. O.: (*a*) Arch. f. klin. Chir. **162**:660, 1930; (*b*) Ztschr. f. Sexualwissensch. **17**:191, 1930.
7. Thomas, A.: Paris méd. **2**:73, 1927.
8. Kovalevsky, P. J.: Rev. neurol. **2**:164, 1925.
9. McDonald, J. R., and Mayo, C. W.: Atrophy of Cremaster Muscle, Arch. Path. **28**:141 (Aug.) 1939; Minnesota Med. **22**:540, 1939.

opinion that the spasms are due to psychogenic influences and originate in the sexual life of the person, thus precluding a neurasthenic background (Hamburger [2]). The second theory was advanced by those authors who saw spasms of the cremaster muscle occur in patients with local or central brain or spinal injuries (Cornil and Mosinger [3] and

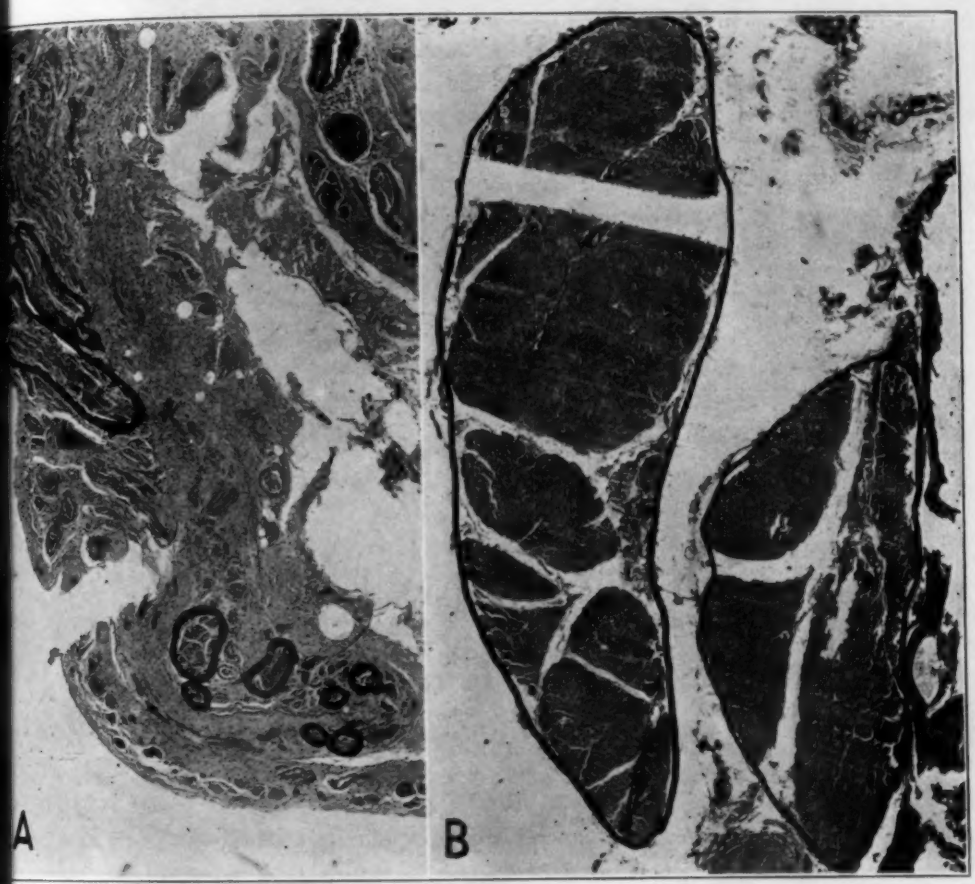


Fig. 2.—*A*, histologic picture of the normal cremasteric fascia; *B*, of the hypertrophied one. Both are magnified thirty-two times. Bundles outlined in black. Actual measurements show the hypertrophied bundles to be twenty-five times larger than normal.

Zucarelli [4]). Zucarelli saw spasms of the cremaster muscle develop in a man after a brain injury in 1 case and after a bullet wound in the thigh in another. A third theory must be sought by those authors who observed spasms of the cremaster muscle in persons free from nervous disturbances and definitely known to be of an opposite mentality, with no local or

central injury. No cause could be found to which one might attribute the origin of the spasms in these patients. In many, the exciting occasion was not sexual at all. In 1 case, the testis would move up and down with each respiration (Kovalevsky [8]). In my case the spasms occurred in a hard working factory worker, mostly during working hours, after he had been on his feet for a number of hours. Haberland [6] analyzed the mental state of his 7 patients and found that only 2 could be classified as neurasthenic; the other 5 had absolutely no symptoms of neurasthenia.

The spasms occur mostly at night and at times of sexual excitement but will also occur during the waking hours. In some instances, stroking of the thighs or a stimulus to the lower parts of the body will elicit a spasm.

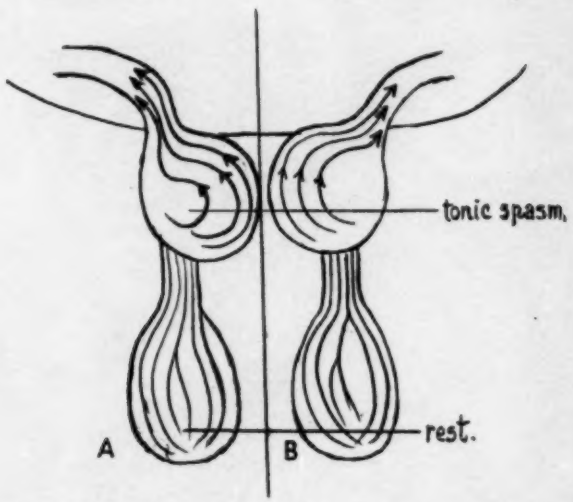


Fig. 3.—Upward pull and inward rotation of testes during tonic spasm as compared with their position at rest (schematic).

SYMPTOMS

The main complaint, which brings the patient to the physician, is pain of varied degree. The character and degree of the pain depend on the type of spasm in the individual case. In clonic spasm the pain is sharp and radiates upward into the loin but lasts only as long as the spasm, usually ten to twelve minutes. These cases are rare. In the majority of the cases observed the spasm is tonic. The pain is not as severe as in the clonic type but lasts longer and, because of the frequent recurrence, becomes annoying. In my case, the spasm had the character of a tetanic contraction; both testes were pulled upward and inward and kept in this position of painful compression for several hours (fig. 3). The only way the patient could stop the spasm was to lie down; the spasm would then gradually quieten. On several occasions he had to stop working

for an entire day. In most other cases reported, the pain occurred during the night and would cause sleeplessness. In others, the spasms were brought on by the slightest sexual irritation and, because of the extreme pain, made coitus impossible.

The history varies from several weeks to several years. My patient gave a history of three months; others reported three years and over (Haberland [8] and McDonald and Mayo [9]).

PATHOLOGIC FACTORS

An extensive study of the cremaster muscle was undertaken by McDonald and Mayo,[9] who examined 80 specimens obtained at autopsies and at operations. In 9 instances, they found the cremaster muscle normal. In 42, the muscle showed atrophy. In 29, the muscle was infiltrated with lymphocytes. In none did they find hypertrophy of the muscle. They observed hypertrophy of the muscle only in their reported operative case. This single instance of hypertrophy in 80 cases indicates the extreme rarity of the condition and explains why cremasteric spasm is seen in the clinic in only a few cases. In my case, there was tremendous hypertrophy of the muscle. In order to determine the degree of hypertrophy, a comparison with normal cremaster muscles was made. The size of the muscle bundles was measured under the microscope, with the aid of a ruled ocular. The table shows the results of this study.

Comparative Measurements of the Muscle Bundles of Normal Cremaster Muscles and a Cremaster Muscle with Hypertrophy

Patient from Whom Obtained	Condition of Cremaster Muscle	Age, (Yr.)	Disease	Length of Muscle Bundles (Microns)
1	Normal	22	Emaciation	20 to 60
2	Normal	54	Pneumonia	40 to 80
3	Normal	30	Accident	60 to 200
4	Spastic	24	Operation	1,700 to 2,600

The average muscle bundle measures about 120 microns. In my case, the muscle attained a remarkable degree of hypertrophy, measuring up to 2,600 microns.

TREATMENT

Several forms of treatment have been suggested by various authors. The same therapeutic procedure gave opposite results in the hands of different men. Drug therapy combined with psychotherapy was advocated by Hamburger.[2] He expressed the belief that neurasthenia is the underlying cause of the spasms. Treatment, therefore, should aim to reduce the irritability of what he called an exaggerated cremasteric reflex.

This regimen, however, has not been of value in the experience of other investigators. Section of the spermatic nerves was tried by Haberland [6] without effect, while Talmud [8] claimed to have obtained a permanent cure by this procedure. Excision of the inguinal nerves by Haberland gave only temporary relief. He noted similar temporary improvement, lasting two weeks, after spinal anesthesia. He also tried injections of an estrogen and observed only slight temporary improvement. Partial excision of the cremasteric fascia around the spermatic cord gave no results in Haberland's case, while in the case of McDonald and Mayo [9] it resulted in complete cure. Haberland, who reported the largest series of personal cases,[6b] claimed that best results were obtained with hot sitz baths and diathermy.

There is no report in the literature of the complete bilateral removal of the cremasteric fascia, as carried out in the case herein reported. A complete and permanent cure was obtained. Follow-up examination showed complete absence of any scarring or induration of the scrotal contents on either side. The cremasteric reflex, as one would expect, was completely absent on both sides. There was great improvement in the patient's general condition, both mental and physical. He regained the weight lost during the three months previous to the operation, and his mental outlook returned to normal. He pursued his daily work with vigor, unhindered by any sensation in either side of the scrotum.

STAINLESS STEEL AND VITALLIUM IN INTERNAL FIXATION OF BONE

A COMPARISON

J. ALBERT KEY, M.D.
ST. LOUIS

The earlier work on the internal fixation of bone was done with corrosive metals, because suitable noncorrosive metals were not available. For the most part, surgeons emphasized aseptic technic and adequate mechanical fixation as the important factors in determining the success or the failure of an operation. For instance, Groves,[1] as a result of 100 experiments on animals, concluded that ordinary steel plates were well tolerated by the tissues and that long plates fixed with cotter pins were more efficient than short plates fixed with screws, because the screws soon became loose when subjected to mechanical force and caused the fixation to fail before union occurred.

There was, however, some interest in the reaction of tissues to various metals, and von Baeyer,[2] in 1908, in an extensive monograph described the cellular reaction around pieces of metal which were left buried in the tissues for varying periods. The metallic particles set free by corrosion were identified in the surrounding tissues, and the cellular reactions were described in detail. He also noted that when two different metals, copper and zinc, were implanted close together rhythmic contraction occurred in the underlying muscles and the connective tissue cells were arranged in the direction of the electric current. In a second paper von Baeyer [3] noted that when small rolls of zinc and copper were placed beneath the skin of a rabbit and left for several months the copper remained shiny instead of corroding, the copper ions migrated toward and united with the zinc instead of becoming oxidized or dissolved and the copper was no longer poisonous to the cells. He stated that the general phenomenon of electrolysis occurred with other metals, such as

From the Department of Surgery of the Washington University School of Medicine.

1. Groves, E. W. H.: An Experimental Study of the Operative Treatment of Fractures, Brit. J. Surg. **1**:438, 1913.

2. von Baeyer, H.: Foreign Bodies in the Tissues, Beitr. z. klin. Chir. **58**:1, 1908.

3. von Baeyer, H.: The Relation of Metallic Zinc and Copper in the Tissues, München. med. Wchnschr. **56**:2416, 1909.

steel and copper and caused the iron to rust quickly and that before advantage could be taken of the electrolytic processes in surgical procedures the various combinations of metals would have to be studied further.

Zierold [4] studied the reaction of bone to various metals and noted that it was indifferent to the implantation of some metals and sensitive to the introduction of others. The metals of the first type were found to be unchanged after having been buried in the tissues for some time, but those of the second type exhibited evidence of varying degrees of corrosion. He stated that in mass form a metal could modify other elements only at the expense of its own substance, that in an electrolyte this was accomplished by the dissociation of metallic ions to the end that a colloidal solution was formed which conformed to the solution pressure of the metal, that this process underlay the phenomenon which is termed corrosion and that this explains the changes which occur in steel and iron when they are exposed to the action of an electrolyte (tissue fluids). It was his conclusion that of the metals studied gold, aluminum and stellite (an alloy of cobalt, chromium and tungsten) were readily tolerated by bone and tended to become encapsulated with but little hindrance to the reparative process. They appeared to be inert and unaffected by the living cells and body fluids. He further noted that steel, which was poorly tolerated and readily soluble, seemed to be the least suitable of all metals for fixation of bone.

Stainless steel was first introduced in surgery as the Krupp steel wire, which was used for bone sutures. Lange [5] studied the reactions of the bone and the soft tissues of experimental animals to this wire and compared the results with those of similar experiments performed with wire made of iron and bronze. From microscopic and clinical data he concluded that the Krupp steel wire was the ideal suture material for bone, as it was strong, caused no reaction in the tissues and interfered less with the building of callus than did wire of iron or aluminum bronze.

Jones and Lieberman [6] compared the interaction of bone and stainless steel with that of bone and vanadium steel in experimental animals. They emphasized the fact that there was a considerable number of stainless steels on the market and that they varied greatly in composition. They studied nickel-free rustless steel, high nickel rustless steel, low nickel rustless steel and vanadium. The method used was to bury tacks in the bones of experimental animals, leave them for from one to two and one-

4. Zierold, A. A.: Reaction of Bone to Various Metals, Arch. Surg. **9**:365 (Sept.) 1924.

5. Lange, M.: Krupp Steel Wire as Bone Suture Material, Ztschr. f. orthop. Chir. **47**:520, 1926.

6. Jones, L., and Lieberman, B. A., Jr.: Interaction of Bone and Various Metals, Arch. Surg. **32**:991 (June) 1936.

half months and then determine their loss in weight; the reaction of the surrounding bone to the metals was also studied. They concluded that the intensity of reaction in the bone was directly proportional to the chemical changes which occurred in the metal with which it was in contact and that such changes might be grouped under the general term corrosion. They expressed the opinion that the high chromium, low nickel rustless steels were the metals of choice, because corrosion in those alloys was minimal, although they were not completely nonirritant in bone.

Haas [7] also emphasized the fact that stainless steels vary in composition and that some of them corrode relatively quickly. A photograph of a nail of the VM rustless steel which was markedly corroded was reproduced in his paper, and he stated that the V2A steel should be used, as it was about ten times as resistant to corrosion in sea water as was the VM stainless steel.

Orsos [8] emphasized that an electric current is generated when bone is fixed by two different metals and cited a case in which an aluminum plate was placed on the humerus in close contact with the radial nerve. As soon as the brass screw came in contact with the aluminum plate there was a strong contraction of the muscles, with extension of the hand and fingers. This was due to the electric current generated by the two metals in an electrolyte, as under these conditions they formed a small galvanic element. In Ringer's solution the current amounted to 0.25 milliampere and gradually decreased after about fourteen hours to 0.08 milliampere, at which level it remained constant. Orsos expressed the opinion that only a homogeneous metal, with which an electric current could not be formed, should be used, and he recommended employing an autoplastic bone plate fixed by a single wire to either fragment.

Ménégaux, Moÿse and Odiette [9] and others studied the influence of metals on the growth of fibroblasts and other cells in tissue cultures. They found that copper, magnesium, aluminum bronze and brass were very toxic. Silver, nickel and chromium were moderately toxic, while gold, V2 extra stainless steel and platinostainless D steel were neutral and had a minimal toxicity. Consequently, metals of the last group were recommended for the internal fixation of bone. They expressed the

7. Haas, W.: "Rustfree" Steel in Surgery, Arch. f. orthop. u. Unfall-Chir. **37**:606, 1936.

8. Orsos, E.: The Current Generated by Bone Sutures, Zentralbl. f. Chir. **56**:1014, 1925.

9. Ménégaux, G.; Moÿse, P., and Odiette, D.: Growth of Connective Tissues of Bone in Tissue Cultures in the Presence of Certain Metals, Presse méd. **42**:658, 1934. Ménégaux, G., and Odiette, D.: Cytotoxic Action of Certain Metals on Human Osteoblasts in Tissue Cultures, ibid. **43**:1555, 1935.

opinion that two metals of different nature in association did not have an action different from that of the isolated metals and that the importance of the electrical phenomena created by the association of two metals was negligible as compared with the toxicity of the metal itself. The results of their tissue culture experiments were confirmed by investigation on animals in which the same metals were placed beneath the periosteum. They concluded that the toxicity depended entirely on the metal and that the tissue reacted the same way to a foreign body whether it was in vitro or in vivo.

Zeinert,[10] on the other hand, emphasized the importance of the electric currents in buried metallic foreign bodies, and to show the influence of such currents he fixed the femurs of rabbits with wires placed in the subcutaneous tissue, according to the method of Magnus. Through one wire a current of 1.5 volts was passed for three seconds daily for eight days. This current caused the wire to corrode, so that the change was similar to that which would have occurred over a period of five months. For this reason he expressed the belief that metals, and he included stainless steels, should be left in the tissues for only a short time.

Perves and Damany [11] reported a case in which there were pain and cyanosis in the forearm after fixation of a fracture with a Lambotte plate and the symptoms were relieved by removal of the plate. They expressed the belief that the symptoms were due to the electric current generated and showed that between the Lambotte screws and the plate there was a difference in potential of 66 millivolts, while between Sherman vanadium steel screws and plates the difference was 44 millivolts and between the Sherman screws and the Lambotte plate, such as were present in their patient, the difference was 52 millivolts. They also tested plates of platinostainless steel with screws of similar material and found that the difference in potential was so slight that it was not measurable.

Masmonteil,[12] likewise, cited 3 cases in which there was profound corrosion of screws and the alterations in potential between the corroded and the noncorroded portions of the screws were measured. This difference varied from 0.134 to 0.153 millivolt. He expressed the belief that the electrolytic phenomenon was the prominent factor in causing the unfavorable reaction of bone to the metals used for osteosynthesis, and he recommended that the metals used be inert chemically and physically and isoelectric with the bone (with a potential of about 0.210 millivolt).

---

10. Zeinert, H.: Electric Currents in Buried Metallic Foreign Bodies, Arch. f. orthop. u. Unfall-Chir. **37**:261, 1936.

11. Perves, J., and Damany, G.: The Importance of the Electrolytic Factor in Osteosynthesis, Mém. Acad. de chir. **64**:650, 1938.

12. Masmonteil, F.: The Tolerance of Bone for Metallic Foreign Bodies. Presse méd. **43**:1915, 1935.

Bothe, Beaton and Davenport [13] buried tacks of various metals close together in the bones of cats and studied them after periods of from eight to two hundred and thirty-two days. They expressed the opinion that electric potentials were not an infallible guide to the amount of reaction between the bone and the metal, and they suggested that electrolysis is an accompaniment of the unfavorable reaction of the bone rather than the direct cause of it. In their experiment each metal retained its characteristic individuality of reaction in spite of the conditions with regard to electrolysis and the inert alloys and titanium remained inert in the presence of reactive metals.

Hudack [14] reviewed the clinical experience at the Presbyterian Hospital, New York, with high chromium, low nickel stainless steel and also reported the results of experiments on 5 dogs in which the bone plates were left in the tissues for periods varying from two days to two years. After removal the plates and screws were weighed. They showed an average loss in weight of approximately 0.1 per cent. The plates were well tolerated and caused no reaction in the bone. Microscopic section showed that the bone was closely approximated to the metal and had grown into the threads of the screw and remained living. He recommended that all stainless steel material should be passivated before use by immersion in 20 per cent nitric acid at a temperature of 65 C. (149 F.) for a half hour or more. This creates a chromic oxide coating on the steel. He also recommended that the steel be polished before being subjected to the passivating process.

Venable, Stuck and Beach [15] placed screws of vitallium, copper, brass, galvanized iron, vanadium steel, plain steel and chromium-plated and silver-plated copper in the bones of animals and studied the bones and the screws at intervals which varied from a few days to three months.

---

13. Bothe, M. F.; Beaton, L. E., and Davenport, H. A.: Reaction of Bone to Multiple Metallic Implants, Surg., Gynec. & Obst. **71**:598, 1940.

14. Hudack, S.: High Chromium, Low Nickel Steel in the Operative Fixation of Fractures, Arch. Surg. **40**:867 (May) 1940.

15. Venable, C. S.; Stuck, W. G., and Beach, A.: The Effects on Bone of the Presence of Metals Based upon Electrolysis: Experimental Study, Ann. Surg. **105**:917, 1937. Stuck, W. G.: Electrolytic Destruction of Bone Caused by Metal Fixation Devices, J. Bone & Joint Surg. **19**:1077, 1937. Venable, C. S.: Electrolytic Action Between Metals in Bone Surgery, Arch. Phys. Therapy **19**:285, 1938; Osteosynthesis in the Presence of Metals: Studies on Electrolysis, South. M. J. **31**:501, 1938. Venable, C. S., and Stuck, W. G.: Fractures: Recent Advances in Treatment with Non-Electrolytic Metal Appliances, J. Indiana M. A. **31**:335, 1938; Electrolysis Controlling Factor in the Use of Metals in Treating Fractures, J. A. M. A. **111**:1349 (Oct. 8) 1938. Venable, C. S.: Application of Neutral Metal in Fractures, South. Surgeon **8**:456, 1939. Venable, C. S., and Stuck, W. G.: Vitallium Nails in Fractures of the Hip, Surg., Gynec. & Obst. **70**:964, 1940.

They found that screws made of all the metals except vitallium caused reaction and absorption in the bone and became loose. They expressed the opinion that this unfavorable effect on bone was due to electrolysis, which was caused by variation in the local electric resistance of the metals. They deserve great credit for calling the attention of American surgeons to this aspect of the internal fixation of bone. As a result of their observations, vitallium was recommended as the material of choice for the internal fixation of bone.

Since there appears to have been no comparative study of vitallium and the better grades of stainless steel, which are the materials now commonly used for the internal fixation of bone, it seemed worth while to make the present study.

EXPERIMENTAL OBSERVATIONS

In the beginning the standard 18-8 stainless steel was used. This contains 18 to 20 per cent chromium, 8 to 10 per cent nickel, 65 to 70 per cent iron and small amounts of carbon, manganese, silicon, phosphorus and sulfur. This is the steel which is now used by most instrument houses in this country for manufacturing materials, such as screws, plates, wires and nails, which are intended for the internal fixation of bone. About three months ago, I obtained from the Zimmer Manufacturing Company some screws and plates made of a new stainless steel known as enduro, or 18-8 S-MO. This steel contains from 16 to 20 per cent chromium, a maximum of 14 per cent nickel and from 2 to 4 per cent molybdenum. It has been introduced for use in surgical procedures on bone largely through the efforts of Dr. J. A. Carnes, of Massillon, Ohio. I have obtained further supplies of this material and certain data on it from Dr. Carnes.

Animal Experiment 1.—The first experiment consisted of the implantation of a series of nails, plates and screws in the femurs of 6 dogs. Prostheses made of stainless steel were placed in one femur, and similar prostheses made of vitallium were placed in the other femur of each animal. The operations were performed with the animal under general anesthesia, under aseptic conditions. The dogs were maintained for thirteen months and were then killed. Unfortunately, 1 dog was lost; so only the observations on the 5 remaining animals could be used to reach conclusions. Each femur contained six or more pieces of metal. In one instance there was a mild infection in one wound, which caused some excess growth of new bone.

The bones were removed and fixed in solution of formaldehyde at the end of the experiment. A small piece was taken for microscopic study from both femurs of 1 animal. In all of the animals the vitallium and stainless steel screws remained firmly fixed in place. The same was true

of the plates. None were loose. There was no evidence of any absorption of bone around any of the screws or under any of the plates (fig. 1). In 1 animal, however, both the stainless steel nail and the vitallium nail, which were driven into the trochanteric region of the femurs, were loose. This was due not to absorption of bone or corrosion of the nails but to the fact that the nails had been improperly inserted and passed through only a small amount of cancellous bone. The same error occurred in inserting the nails in both femurs of the animal. It should be stated that none of the nails, screws or plates were passivated before they were used.

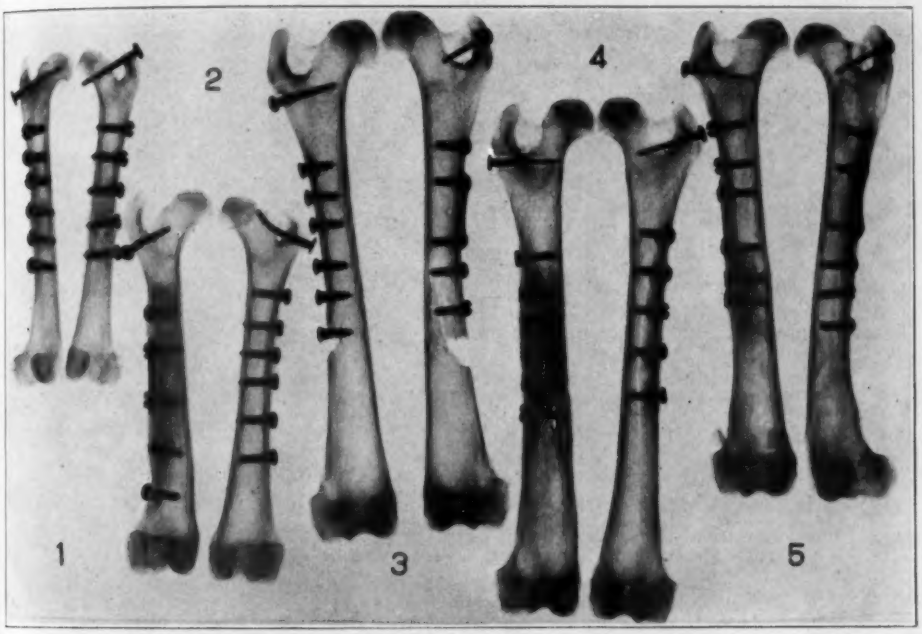


Fig. 1.—Paired femurs of 5 dogs thirteen months after the insertion of screws and nails. The screws and nails in the right femurs were of vitallium and those in the left femurs were of stainless steel. Specimens were removed from *3* for microscopic examination.

It was found that some of the plates and screws were partly covered by new bone and that a thin film, or capsule, of connective tissue covered the heads of the nails, screws or plates where they projected from, and were not covered by, the bone. At the time of the removal of the bones from the body none of the metal showed any evidence of corrosion. However, the bones were placed in a 10 per cent concentration of solution of formaldehyde U. S. P. and left for about nine months before they were cleaned and dried. During this interval in solution of formaldehyde

there appeared definite staining of tissues around some of the stainless steel nails, screws and plates. The staining was slight, but still it was definite. A similar staining of the tissues did not occur around the nails, screws or plates of vitallium. Also, it is to be noted that in the femurs which contained the stainless steel material there was a slightly greater amount of periosteal and endosteal new bone formation than there was around the vitallium.

Animal Experiment 2.—The second experiment consisted of cutting the two femurs of dogs obliquely and fixing them. In one femur plates and screws of stainless steel were so applied that the femur was rigidly fixed. In the opposite femur stainless steel wire was used, and the bone was fixed so that there was a small amount of play. The object of the experiment was to determine whether or not rigid internal fixation was advantageous for the union of bone. Unfortunately, the experiments have not been extensive enough to allow any conclusions to be drawn, and in several animals the plates bent or the femurs broke where they were drilled. As a result of these mishaps the wounds became infected, and the animals were killed. In those animals in which the internal fixation was mechanically strong enough to stand the strain of ordinary use, the bones united in the normal manner, regardless of whether they were rigidly or loosely fixed; and in none of these was there any evidence that the stainless steel wires, plates or screws interfered in any way with the normal union of the bone, and some of these bones united with a minimum of callus.

In microscopic sections of bone adjacent to the screws there was no evidence of any absorption or inflammatory reaction, and living bone was in direct contact with the metal and projected in between the threads. This was true of the bone around both the stainless steel and the vitallium screws.

Experiments to Determine Corrosibility.—In order to test the resistance of the stainless steel and of the vitallium to corrosion, screws, plates and nails were placed in physiologic solution of sodium chloride and left for six months or longer. It was noted that a variable amount of corrosion occurred in those jars which contained only the stainless steel and that the solution after a few days was stained brown. The reddish brown material, or rust, accumulated in the bottom of the jars or bottles. As the process continued the steel remained bright, but sharply localized pitting of some of the nails and plates was noted. This was particularly true of a group of old Smith-Petersen nails and old plates of stainless steel which were apparently not made of the 18-8 material.

However, if even the modern 18-8 stainless steel was left in the salt solution for several weeks or months, there occurred a variable amount of localized corrosion, with staining of the surrounding fluid. On the other

hand, if a piece of aluminum or a piece of vitallium was placed in the same vessel, the corrosion of the stainless steel was inhibited. In the case of the aluminum there was a considerable amount of corrosion, and the corroded material was set free in the fluid. Apparently, there must have been some corrosion of the vitallium, for otherwise it would not have been possible to inhibit the corrosion of the stainless steel by having vitallium present in the solution. There must be an electric current established between the inhibiting metal, that is, aluminum or vitallium, and the stainless steel in order to prevent the corrosion of the steel.

When pieces of copper were placed in the same solution with the stainless steel, they tended to accelerate the corrosion. The same was true of pieces of copper placed in salt solution with vanadium steel. Aluminum, on the other hand, tended to decrease the corrosion of vanadium steel but by no means prevented it, as it did in the case of the 18-8 stainless steel.

To test the effect of immersion in salt solution, pieces of 18-8 S-MO, or enduro, stainless steel, were placed in the salt solution and kept in an oven at 58 C. (136.4 F.) for two months in order to accelerate any changes due to corrosion or electrolysis. This experiment was controlled by keeping similar jars containing stainless steel, vanadium steel and vitallium under the same conditions. The vitallium and the 18-8 S-MO, or enduro, steel showed no evidence of corrosion over the period of two months at the elevated temperature, whereas the other steels showed corrosion. Apparently, the increased temperature accelerated the corrosive process. It is thus evident that vitallium is less subject to corrosion than is standard 18-8 stainless steel and is practically the same in this respect as is the enduro stainless steel.

Physical Properties of Vitallium and Stainless Steel.—Vitallium is an alloy which must be cast and cannot be machined or drawn out to form wire. Consequently, its use is limited to the type of prostheses which can be made by casting. Likewise, it is subject to the limitations of cast products; that is, the vitallium screw or plate may contain blow holes or air holes and is subject to shrinkage. Stainless steel, on the other hand, can be cold rolled, machined and drawn into wire, and its hardness and brittleness can be altered by tempering. It has also been noted by Dr. J. A. Carnes that the resistance to vibration of vitallium is relatively slight as compared with that of 18-8 stainless steel. The vitallium plate broke after being vibrated 47 times, while that of stainless steel broke after being vibrated 2,000 times. Likewise, the vitallium cracked when bent to an angle of 25 degrees, while the stainless steel cracked when bent to an angle of 180 degrees (Carnes[16]). A stainless steel plate was bent approximately 25 degrees by a force of 25 pounds (11.3 Kg.),

16. Carnes, J. A.: Personal communication to the author.

while a vitallium plate of approximately the same size and shape was bent to a similar angle by a force of 12 pounds (5.4 Kg.).

In an attempt to measure the difference in electric potential two 18-8 stainless steel plates or screws were placed in salt solution and a microammeter was attached to each; the current produced was scarcely sufficient to move the needle of the ammeter. When enduro steel or vitallium was tested under the same conditions there was usually no perceptible movement of the needle, but sometimes a slight movement was seen. In other words, it is believed that the electric current between two pieces of stainless steel is not strong enough to be of any importance, but it is slightly more marked than is the current generated by two pieces of vitallium or by two pieces of enduro stainless steel under the same conditions.

COMMENT

My observations indicate that vitallium has a slight advantage over ordinary 18-8 stainless steel as regards corrosion, or electrolysis (the terms may be used interchangeably). However, it does not seem to have any such advantage over enduro, or 18-8 S-MO, stainless steel, which is now available at relatively small cost and can be obtained by all instrument makers. Stainless steel has a great advantage over vitallium in that it can be machined and drawn into wire, cold rolled and tempered to varying degrees of hardness. It is also stronger than vitallium, is less brittle and is more resistant to fatigue. Finally, vitallium is relatively expensive, and its output is controlled by one company, while stainless steel is relatively cheap and is readily available from many sources.

The question that arises is how important is the slight amount of corrosion which may occur in 18-8 stainless steel plates and screws which are left in the body over a period of years. It is my opinion that corrosion, or electrolysis, if one prefers to use that term, has relatively little to do with the success or the failure of the operation when a prosthesis is used for the internal fixation of bone.

Even when corrosive material was used I never had to remove a prosthesis because the metal caused infection, absorption or softening of the bone or interfered with the formation of callus. On one occasion I removed a Parham band from the tibia, and on another occasion I removed screws from a bone graft of the tibia. The Parham band had been in place eight years, and at the end of this time, when the patient had reached maturity, redness, edema and pain developed over the site of the band. It was removed with considerable difficulty, because it was corroded and almost completely covered by bone. The screws which I removed had been used to fix a bone graft on a tibia which had been badly infected. After union occurred one of the screws became painful. All of these screws, which were of vanadium steel, were found to be loose and were removed. I have on many occasions fixed bone grafts to bone

with vanadium steel screws, and with the exception of those used in the case mentioned, I believe these screws are still in place. Vanadium steel screws were used because stainless steel screws of the Sherman self-tapping type were not available in this country until three or four years ago.

It has been my experience that if the vanadium steel screw is properly placed and is not too close to the skin it, or the plate which it may have been maintaining in position, can remain in place indefinitely. On the

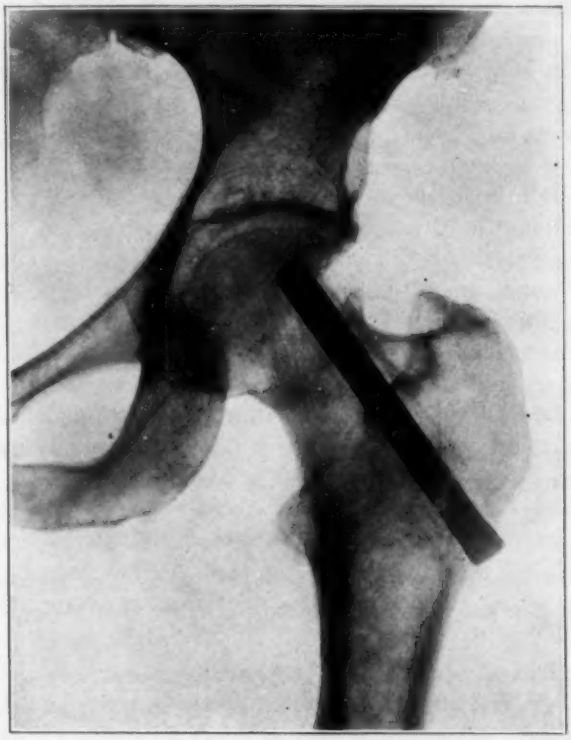


Fig. 2.—Site of fracture of the hip over five years after nailing. In spite of the marked corrosion of the old type, stainless steel nail there are no symptoms.

other hand, if it is close to the skin it probably will have to be removed. The same is true of the ordinary soft iron, or stovepipe, wire which was used before stainless steel was available. I have not had to remove it on account of corrosion, or electrolysis.

When stainless steel wire, screws and nails became available I began to use them and have used them since. On no occasion have I had any trouble which could be attributed to the material of which the wire, nail or screw was composed. Venable and Stuck suggested that corrosion of

chromium-plated steel plates might cause chromium poisoning. Figure 2 shows a nail which was made of the wrong kind of stainless steel. After five years it is markedly corroded and has even been corroded in two, and yet the patient is in perfectly normal health, has maintained firm union and has an apparently normal hip. I believe that the chromium is not liberated in a poisonous form.

I have removed nails from hips only because they projected too far out from the bone and caused pain, because there was failure of union, because there were absorption and shortening of the neck of the femur before union occurred or because of necrosis of the head of the femur. I have not removed any stainless steel prosthesis on account of corrosion, nor do I know of any instance in which this has been necessary when 18-8 stainless steel was used. For the internal fixation of bone a prosthesis of vanadium steel or other corrosive metal may be used with confidence if a suitable prosthesis of stainless steel or vitallium is not available. If it is sterile and mechanically right, such a prosthesis will maintain fixation until union has occurred, and its removal will rarely be necessary unless it is too close to the skin.

As was noted in the incomplete review of the literature which is included in this paper, several observers have warned against placing two different metals close together in the tissues, because they then form a small battery and the electric current which they generate accelerates corrosion and may even affect the tissues. This is undoubtedly true of corrosive metals. Whether it is true of noncorrosive metals, such as the various stainless steels and vitallium, is doubtful.

CONCLUSIONS

Vitallium, 18-8 stainless steel and 18-8 S-MO, or enduro, stainless steel are inert in the tissues, and all are suitable for the internal fixation of bone.

The mechanical advantages of the stainless steel of the 18-8 type outweigh its slight tendency to corrosion, or electrolysis; and it is a more generally useful material for the internal fixation of bone than is vitallium.

The 18-8 S-MO, or enduro, stainless steel is even more suitable than is the ordinary 18-8 stainless steel.

The Fracture Committee of the American College of Surgeons should recommend the standardization of 18-8 S-MO, or enduro, stainless steel for the manufacture of prostheses for the internal fixation of bone and should require such prostheses to be properly labeled or stamped in order that surgeons may know what type of stainless steel they are using. The prostheses should be passivated by the manufacturer.

When and if a more suitable material is discovered, it should be adopted.

TRAUMATIC CHYLOTHORAX

DEAN D. SMITH, M.D.
AND
EDWARD WOLIVER, M.D.
CINCINNATI

Traumatic chylothorax is a relatively rare condition. In a recent comprehensive review of the subject, Shackelford and Fisher [1] were able to collect only 43 authentic cases. They not only emphasized the rarity of traumatic chylothorax but also stressed the difficulty both of making an early diagnosis and of treating this condition. The reported mortality is approximately 50 per cent in spite of the various methods of therapy.

The causation of chylothorax has been summarized by McNab and Scarlett [2] as follows:

I. Trauma
  a. Closed trauma
    1. Without fracture of bone
    2. Accompanied by fracture of ribs, clavicle or vertebrae
  b. Operative wounds
    1. Duct severed
    2. One or more terminals severed
  c. Gunshot or stab wounds

II. New growth or granuloma outside the duct: carcinoma, lymphosarcoma, tuberculous glands

III. Thrombosis of the left subclavian vein

IV. New growth within the duct

V. Perforating lymphangitis

VI. Aneurysm of the duct

VII. Cirrhosis of the liver

VIII. Filariasis

The anatomy of the thoracic duct has been well described by numerous authors.[3] Several facts are worthy of repetition, namely, that the

1. Shackelford, R. T., and Fisher, A. M.: Traumatic Chylothorax, South. M. J. **31**:766-775, 1938.

2. McNab, D. S., and Scarlett, E. P.: Traumatic Chylothorax Due to Intrathoracic Rupture of Thoracic Duct, Canad. M. A. J. **27**:29-36, 1932.

3. Rouvière, H.: Anatomy of the Human Lymphatic System, translated by M. J. Tobias, Ann Arbor, Mich., Edwards Bros., Inc., 1938.

duct is normally present on the right side in the lower part of the thorax and that anomalies of displacement and doubling of the duct occur.

The physiologic significance of a ruptured thoracic duct is readily understood when one realizes that 60 per cent of ingested fat passes along the duct channel,[4] that from 130 to 195 cc. of chyle is conducted each hour through the duct to the veins of the neck and that in cases of rupture frequently 2 liters or more of chyle collects daily in the chest. The protein content of the chyle varies from 1 to 6 Gm. per hundred cubic centimeters.[5] Such a loss of fluid so rich in protein and fat leads readily to inanition and dehydration if not replaced by various forms of therapy.

In a recent case of chylothorax following an operative procedure, which is the first one of its type to be reported, we were able to make certain studies which have not hitherto been reported and to employ more extensively than ever before the therapy of returning the aspirated chyle intravenously to the patient.

REPORT OF A CASE

A 17 year old white girl entered the hospital Feb. 5, 1941 with a sarcoma on her right tenth rib. Her general health was good. In the region of the right ninth and tenth ribs posteriorly there was a diffuse smooth swelling. A friction rub could be heard over the tumor, but no alteration in the lung tissue could be made out. Roentgenograms of the chest showed destruction of the right tenth rib extending from the rib's attachment with the vertebra nearly to the costochondral junction (*A* in fig.). Roentgenograms of the remainder of the skeletal system revealed no abnormalities. A general physical examination, including laboratory studies, revealed nothing of importance.

At operation all but a short segment of the anterior portion of the tenth rib was resected. The pleura beneath and the intercostal muscles above and below it were excised. The lesion was Ewing's tumor of the rib. It extended well into the thoracic cavity and over close to the body of the tenth vertebra. The large vessels were ligated with silk, but some general ooze in the bed of the wound was controlled with the Bovie unit. Just before closing the chest Dr. Mont Reid, the operator, noted some turbid fluid welling up in the bed of the wound and suspected that the thoracic duct had been resected with the growth. The duct could not be seen or ligated. Before the dressing was applied, all the air was aspirated from the chest. Complete expansion of the lungs was confirmed by a roentgenogram taken immediately after operation.

The first two postoperative days were relatively smooth. On the third day, after a severe coughing spell, the patient experienced a sharp pain in the right side of the chest. She became dyspneic but not cyanotic. Physical examination at the time revealed fluid in the right side of the chest; this was confirmed by

4. Bloor, W. R.: Fat Transport in the Animal Body, Physiol. Rev. **2**:92-115, 1922.

5. Drinker, C. K., and Field, M. E.: Lymphatics, Lymph and Tissue Fluid, Baltimore, Williams & Wilkins Company, 1933.

roentgenogram. On the fifth postoperative day a thoracentesis was performed, and 900 cc. of turbid pink-tinged liquid was obtained. Both smear and culture of the fluid were negative for bacteria. The specific gravity was 1.019. Wright's stain revealed numerous red blood cells and a few white blood cells (90 per cent lymphocytes). With sudan III stain, many fat globules were seen, and a lipocrit determination [6] revealed 0.36 cc. per hundred cubic centimeters of fluid. On the basis of these examinations we believed the fluid to be chyle.

During the course of the next twelve days 7,800 cc. of chyle was removed by five thoracenteses (*B* in fig.). After the first aspiration the fluid assumed the typical milklike appearance as the blood contamination decreased. Four intravenous administrations of chyle were given, totaling 3,000 cc. After the fifth thoracentesis on the fourteenth postoperative day there was no further accumulation of chyle.

After the fifth postoperative day the patient's temperature was never elevated above 99 F., except for a mild thermal reaction after an intravenous treatment. The patient was discharged on her twenty-fourth postoperative day. A roentgen examination of the chest then revealed no evidence of reaccumulation of chyle (*C* in fig.). At the time of her discharge from the hospital her nutrition and strength were good; the total loss in weight was only 10 pounds (4.5 Kg.). At the time of writing, she had been home for two months and in spite of high voltage roentgen therapy had regained 8 pounds (3.6 Kg.).

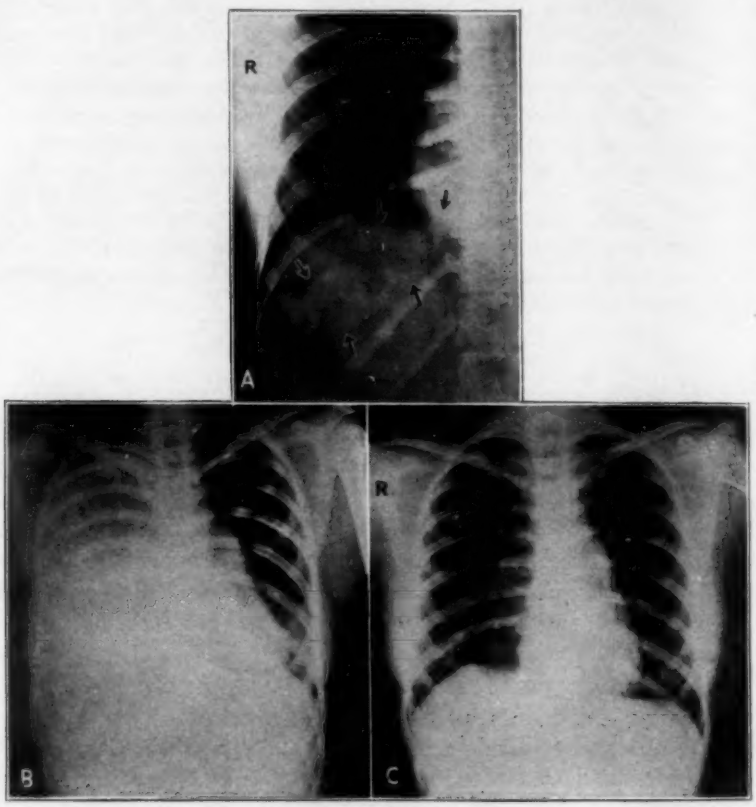
COMMENT

The chylous fluid removed in this case exhibited the following characteristics: It was a milklike fluid that formed three layers on standing, an upper "cream" layer, a middle "milk" layer and a lower sediment layer, consisting chiefly of the cellular elements. On standing for a long time a small coagulum formed. The specific gravity ranged from 1.016 to 1.025. The protein content varied from 3 to 6 Gm. per hundred cubic centimeters. These values were checked by both the falling drop and the Kjeldahl methods. The presence of fat was determined by three methods: (1) staining with sudan III, (2) shaking the chyle with ether and (3) the lipocrit method.[6] By the latter method the fat content varied from 0.4 to 2.8 cc. per hundred cubic centimeters. The chyle was always alkaline in reaction and contained relatively few red blood cells and leukocytes, 90 per cent of the latter being lymphocytes. Repeated cultures of the aspirated chyle were sterile.

Numerous investigators [5] have emphasized the decrease of lymphocytes circulating in the blood after ligation of the thoracic duct. In our case we noted a drop in the percentage of lymphocytes from 39 before operation to 17 three days after operation. This persisted without return to the preoperative level. We mention this point as a possible aid to diagnosis in cases in which injury of the thoracic duct is suspected.

6. Herrmann, L. G.; Ames, A., and Tapke, R. J.: Observations upon the Lipokrit Method, J. Lab. & Clin. Med. **19**:411-421, 1934.

The treatment of chylothorax must satisfy several requirements, namely, prevention of the loss of chyle, maintenance of nutrition and prevention of infection in the chest. As traumatized thoracic ducts often close or heal spontaneously, and as operation is not often feasible because of the inaccessibility of the duct or because of the patient's condition, we feel that operation is not advisable, at least during the



A, roentgenogram taken before operation, revealing tumor on the right tenth rib. *B*, roentgenogram of the chest taken fourteen days after operation, revealing extensive chylothorax on the right side. *C*, roentgenogram of the chest taken on the day of discharge from the hospital, revealing no reaccumulation of chyle.

early stages. In our case we instituted conservative therapy, aspirating the chyle to prevent respiratory distress and giving the patient a diet low in fat to decrease the flow of chyle. To satisfy the nutritional requirements of the patient we felt that the intravenous administration of the chyle was the most physiologic. Oral and rectal administration of chyle have been reported, and two investigators have given chyle

intravenously in the past. Bauersfeld [7] in 1937 gave his patient 1,200 cc. of chyle intravenously without a reaction. However, this therapy was instituted sixteen days after the original injury, and by this time the patient was quite weak and emaciated. Bauersfeld stated that after the administration of the chyle the patient promptly improved. The chyle ceased to reform in the chest, and the patient recovered. Oeken [8] in 1908 attempted this procedure, but the patient did not recover. By early intravenous administration of the chyle in our case we prevented the weakness and wasting that result from the loss of this fluid.

TABLE 1.—*Examinations of the Blood of a Patient with Traumatic Chylothorax*

Date	Erythrocyte Count	Hemoglobin (Gm.)	White Blood Cell Count	Lymphocytes	Polymorphonuclears	Monocytes	Eosinophils	Basophils	Hematocrit (Volume per Cent)	Plasma Protein (Gm. per 100 Cc.)
2/ 6/41	4,250,000	12.2	5,600	39	55	3	2	1		
				(Before operation)						
2/ 9/41	3,830,000	....	6,200							
2/13/41	3,920,000	11.6	8,050	17	80	3	0	0		
2/14/41	4,530,000	12.7	10,150	..	..	..	..	..	45.0	6.15
2/16/41	5,140,000	14.9	13,400	18	77	0	3	2	48.9	6.13
2/19/41	4,670,000	13.4	6,550	..	..	..	..	..	47.2	7.33
5/12/41	4,150,000	11.4	4,400	25	67	5	2	1		

TABLE 2.—*Examinations of Chyle Obtained by Thoracentcses*

Date	Amount, Cc.	Specific Gravity	Protein, Gm. per 100 Cc.	Fat, Cc. per 100 Cc.	Culture
2/12/41	900	1.0250	6.00	0.4	Sterile
2/13/41	1,500	1.0172	3.38	1.2	Sterile
2/16/41	1,800	1.0252	6.11	1.2	Sterile
2/18/41	2,100	1.0160	2.97	2.8	Sterile
2/21/41	1,500	1.0165	3.14	2.0	Sterile

Hematocrit, lipocrit and plasma protein determinations were made at regular intervals.

In collecting the fluid from the thorax we used the closed technic. Sodium citrate was added to the collected chyle at the time of aspiration to prevent clotting. Cultures were made and the fluid placed in the ice box until a twenty-four hour negative culture had been obtained. Thoracentesis was done only as warranted by the clinical condition of the patient. Five aspirations were performed and a total of 7,800 cc. of chyle removed.

7. Bauersfeld, E. H.: Traumatic Chylothorax from Ruptured Thoracic Duct Treated by Intravenous Injection of Aspirated Chyle, J. A. M. A. **109**:16-18 (July 3) 1937.

8. Oeken: Ein Fall von Zerreissung des Ductus thoracicus infolge Brustquetschung, München. med. Wchnschr. **55**:1182-1183, 1908.

Four intravenous administrations of chyle were given, totaling 3,000 cc. On one occasion the patient experienced a slight chilly sensation, and her temperature rose to 100 F. Other than this, no reactions occurred. It was felt that this slight reaction could be attributed to a too rapid giving of the fluid. We felt no hesitancy in storing the chyle, and chyle as old as four days was given. Determinations of blood fat were made before and after the administration of the chyle. The patient's fasting blood fat level fell slowly over a period of a week from the initial figure of 0.42 to 0.32 cc. per hundred cubic centimeters. We feel that the gradual lowering of the fat level must have been due to the fact that the diet was low in fat and to our failure to reinject all the aspirated chyle. As would be expected, a rise in the blood fat followed each administration of chyle. Twenty-eight days after operation, after the patient had been receiving a regular diet, and no evidence of any further accumulation of chyle in the chest

TABLE 3.—*Observations on Intravenous Administration of Chyle*

Date	Amount, Cc.	Reaction	Blood Fat, Cc. per 100 Cc.		
			Fasting	At End of Injection	Two Hours After Injection
2/17/41	700	None	0.42		
2/19/41	600	Chilly sensation	0.35	0.51	0.38
2/20/41	700	None	0.36	0.55	
2/22/41	1,000	None	0.32	0.61	
3/17/41	...	.....	0.50		

had been noted, the fasting fat level was 0.48 cc. per hundred cubic centimeters. The importance of the third requirement in the treatment of chylothorax, namely, the prevention of infection in the chest, is apparent. Obviously, infected chyle cannot be given intravenously.

SUMMARY

A case of traumatic postoperative chylothorax is presented together with certain observations on the chemistry of the chyle and the patient's blood.

The rarity of this condition is emphasized by the fact that we were able to find only 43 previously reported cases of traumatic chylothorax, in none of which was the condition postoperative.

The rapid emaciation can be prevented by intravenous administration of the aspirated chyle.

Open external drainage of the chyle should be avoided, unless empyema supervenes. The chyle should be aspirated only to relieve respiratory distress, for its accumulation under pressure probably helps to close the fistula.

DIFFERENTIATION OF SURGICAL JAUNDICE FROM SEVERE DAMAGE OF LIVER (SUBACUTE YELLOW ATROPHY) CLINICALLY SIMULATING IT

JOHN H. OLWIN, M.D.
CHICAGO

With the discovery of vitamin K and the development of methods for measuring plasma prothrombin levels, operation on the jaundiced patient lost much of its terror. By simple preoperative and postoperative procedures, abnormal bleeding in most cases of obstruction of the common duct, whether by stone, tumor or stricture, can now be anticipated and prevented. The liver in these cases is usually normal or so little impaired that the prothrombin level is rapidly brought to normal when the body is given an adequate amount of vitamin K and of bile or bile salts. It has been well established that if the prothrombin level remains normal, unusual bleeding in uncomplicated obstruction of the common duct does not occur.

The diagnosis of common duct stone may often be fairly clear, particularly when gallbladder colic, chills, fever and jaundice are present. The preoperative diagnosis of carcinoma of the head of the pancreas or bile ducts may be less positive, since progressive silent jaundice and acholic stools are often the only basis for such a diagnosis. Cholecystography may be of a little aid in these cases.

Laparotomy in the jaundiced patient is still in a great many cases an exploratory procedure. Silent jaundice is usually considered to represent an obstruction of the bile passages due to malignant growth until proved otherwise, and an exploratory operation is done with the faint hope that the obstructing factor is a stone or multiple stones. In cases in which there has been previous operation in the region of the bile passages, stricture may be suspected. When carcinoma of the head of the pancreas or bile ducts is found, either the abdomen is closed without further operation, or one of several procedures to relieve the jaundice is carried out. However, with subacute yellow atrophy or any other severe pathologic condition of the liver, often unsuspected before operation, the patient may fail to survive even an exploratory laparotomy.

From the Department of Surgery, Rush Medical College, and the Presbyterian Hospital.

THE LIVER AS A SOURCE OF PROTHROMBIN

Warner, Brinkhous and Smith first suggested that the measurement of plasma prothrombin may be used as an estimate of liver function.[1b] They demonstrated that dogs having chloroform or phosphorus intoxication show rapid development of prothrombin deficiency, the degree corresponding to the degree of hepatic damage.[1] The return to higher levels corresponds in time and degree to the regeneration of liver tissue. Warner [2] found that rats from which the major portion of the liver has been removed show a rapid drop in plasma prothrombin.

A number of investigators [3] have observed that patients with cirrhosis of the liver have lowered prothrombin levels and that the response to vitamin K therapy in such cases is usually poor. Wilson [4] in a study of patients with and without impairment of the liver compared the hippuric acid synthesis and prothrombin level, determined by the two stage method, as tests of liver function. Both, he found, were sensitive tests of hepatic impairment. It is fairly well established, then, that the liver is the site of prothrombin formation and that damage of the liver is accompanied by a lowering of that substance in the blood plasma.

The prothrombin levels in 62 cases of jaundice have been studied in this laboratory in the past two years by the two stage method of Warner, Brinkhous and Smith.[1a] A positive diagnosis of common duct stone was made in 13 cases and a provisional diagnosis in 4 other cases. Carcinoma of the head of the pancreas was diagnosed and the diagnosis confirmed in 16 cases, carcinoma of the common bile duct in 2 cases, and of the papilla of Vater in 1 case. There were 3 cases in which a clinical diagnosis of catarrhal jaundice was made, and 21 cases in which cirrhosis of the liver was diagnosed on the basis of the history and

1. (*a*) Warner, E. D.; Brinkhous, K. M., and Smith, H. P.: A Quantitative Study of Blood Clotting: Prothrombin Fluctuations Under Experimental Conditions, Am. J. Physiol. **114**:667-675, 1936. (*b*) Smith, H. P.; Warner, E. D., and Brinkhous, K. M.: Prothrombin Deficiency and the Bleeding Tendency in Liver Injury (Chloroform Intoxication), J. Exper. Med. **66**:801-811, 1937.

2. Warner, E. D.: Plasma Prothrombin: Effect of Partial Hepatectomy, J. Exper. Med. **68**:831-835, 1938.

3. (*a*) Scanlan, G. H.; Brinkhous, K. M.; Warner, E. D.; Smith, H. P., and Flynn, J. E.: Plasma Prothrombin and the Bleeding Tendency, J. A. M. A. **112**:1898-1901 (May 13) 1939. (*b*) Bollman, J. L.; Butt, H. R., and Snell, A. M.: The Influence of the Liver on the Utilization of Vitamin K, ibid. **115**:1087-1091 (Sept. 28) 1940. (*c*) Olwin, J. H.: The Intravenous Use of Vitamin K, ibid. **117**:432-435 (Aug. 9) 1941.

4. Wilson, S. J.: Quantitative Prothrombin and Hippuric Acid Determinations as Sensitive Reflectors of Liver Damage in Human Subjects, J. Lab. & Clin. Med. **25**:1139-1145, 1940.

physical findings of a large liver with ascites, edema of the lower extremities and dilated superficial abdominal veins. In these the jaundice was of a mild degree. A diagnosis of acute alcoholic hepatitis was made in 2 cases.

Patients with obstruction of the common duct whether from stone, tumor, stricture or other obstruction may vary widely in their prothrombin levels, depending on the duration of the jaundice and on the general nutrition and diet. Nearly all of these patients, except those in the later stages, showed prompt response to vitamin K therapy, the prothrombin levels coming to near normal in one to four days as a rule, even in instances in which the levels have been extremely low [3e]; in some cases a little longer period is required. Without exception all of our patients showed a material rise.

Patients with hepatic cirrhosis show varying levels of plasma prothrombin; in our series the values of original determinations ran between 30 and 90 per cent. If the damage of the liver is not too severe or has not been present too long, a small percentage of these patients with prothrombin deficiency will show some response to vitamin K therapy. However, in most of them the prothrombin level is little affected, even when large doses of the vitamin and of bile salts are given over long periods. (It is interesting that even though the prothrombin is raised but little, many of these patients are remarkably improved clinically without rest in bed and without other treatment.) In the patients with acute alcoholic hepatitis the prothrombin was originally 57 and 77.6 per cent. After treatment the values for these patients came to 88.8 and 106 per cent, respectively.

TEST OF LIVER FUNCTION

These results indicate that rather than the original prothrombin level, the response of the liver to vitamin K as reflected in the prothrombin rise is the important point in the measure of liver function. In order to eliminate the factor of absorption of vitamin K from the gastrointestinal tract, which in certain cases may be greatly impaired, it has been the routine practice in this laboratory since December 1939 to give the vitamin intravenously. The synthetic 2-methyl-1,4-naphthoquinone (menadione) [5] is effective in small doses; in some cases as little as 0.1 mg. is enough to bring the prothrombin level to normal.[3e] It has been the practice to make an original prothrombin determination and, if this is low, to administer 2 mg. of the material intravenously and recheck the prothrombin after twenty hours. If it is still below 100 per cent, a second dose is given, and the prothrombin level taken again forty-four hours after the first dose. Most patients with good liver function will

5. The yellow crystals were supplied to us by E. R. Squibb & Sons.

show a normal or nearly normal level at this point. Patients who fail to respond normally are then given oral preparations [6] with occasional supplementary intravenous doses of the material, depending on the type of patient being treated. Prothrombin levels are taken at frequent intervals, and, as can be seen in tables 1 and 2, daily improvement in liver function can be accurately followed.

Three patients with severe jaundice failed to show the usual response.

REPORT OF CASES

CASE 1.—A. F., a 65 year old obese white woman, entered the Presbyterian Hospital on Nov. 14, 1939 with a history of slowly deepening jaundice during

TABLE 1.—*Representative Responses in Cases of Obstruction of the Common Bile Duct*

Diagnosis	Prothrombin Level (Per Cent of Normal)							
	1st Day	2d Day	3d Day	4th Day	5th Day	6th Day	7th Day	8th Day
Carcinoma of head of pancreas..	49.5	65.2	....	....	84.9	....	....	....
Carcinoma of head of pancreas..	13.9	22.4	43.3	....	....	....	51.4	39.1
Carcinoma of head of pancreas..	83.5	106.0	....	....	....	....	....	....
Carcinoma of head of pancreas..	88.3	....	115.0	....	....	....	....	....
Carcinoma of head of pancreas..	40.9	67.4	....	....	....	102.2	....	....
Carcinoma of head of pancreas..	39.0	49.1	70.4	....	....	82.3	....	....
Carcinoma of head of pancreas..	45.4	80.4	....	....	91.0	....	....	....
Carcinoma of head of pancreas..	85.6	101.0	....	....	....	....	....	....
Carcinoma of head of pancreas..	83.4	90.4	....	....	....	....	....	....
Carcinoma of head of pancreas..	67.2	84.0	91.2	....	....	....	....	....
Carcinoma of head of pancreas..	82.6	108.3	....	....	....	....	....	....
Common duct stone.....	88.2	103.2	....	....	....	....	....	....
Common duct stone.....	80.7	105.0	....	....	....	....	....	....
Common duct stone.....	88.4	98.5	....	....	....	....	....	....
Common duct stone.....	77.4	84.7	....	....	108.3	....	....	....
Common duct stone.....	79.6	....	85.0	....	94.0	....	....	....
Carcinoma of common duct.....	18.4	50.2	....	69.7	....	78.1	....	....
Catarrhal jaundice.....	39.7	....	....	73.8	....	....	....	....
Catarrhal jaundice.....	57.6	72.3	84.5	....	....	....	....	....

the previous four weeks. She had had a great deal of itching during this time and in the two weeks prior to admission had felt marked loss of strength. During the last week before admission she had noticed a dull soreness in the right upper quadrant of the abdomen. She had had no acute pains, chills or fever. Her appetite had always been good but had failed since the onset of the jaundice. There had been a loss of 10 pounds (4.5 Kg.) during this time. She stated her stools were white to clay colored in the early weeks of the jaundice but in the week before admission were normal in color. Her physician had been giving her "occasional injections" for high blood pressure. An appendectomy had been done in 1909 and a nasal operation in 1914. Her father had died at 101; her mother, at 56 of an unknown cause. Two sisters had died of tuberculosis.

The patient weighed 152 pounds (68.9 Kg.). Her temperature at its highest was 99 F., her pulse rate varied between 60 and 90, and her blood pressure

6. The oral preparation used was menadione (2-methyl-1, 4-naphthoquinone), furnished by E. R. Squibb & Sons, Eli Lilly & Co., Parke, Davis & Co. and Abbott Laboratories.

measured 174 systolic and 64 diastolic. The skin and scleras were jaundiced. Her liver was not palpable, but slight tenderness could be felt below the right costal margin. Her hemoglobin measured 80 per cent of normal; the red blood cell count was 4,100,000, and the white blood cell count was 15,000. The icterus index was 165; the direct van den Bergh test gave an immediate positive reaction. One stool obtained was light brown and showed a 1 plus benzidine reaction. The urine contained albumin (3 plus), bile (4 plus) and an occasional white blood cell. Bleeding time as measured by the Duke method was three minutes; the coagulation time was two and a half minutes.

A preoperative diagnosis of obstructive jaundice, probably from the carcinoma of the head of the pancreas, was made.

The prothrombin level as measured by the two stage method the day after admission was 26.8 per cent. The patient stated she had been receiving vitamin K before she came to the hospital. Following the determination of prothrombin, she was given 1 mg. of menadione (2-methyl-1, 4-naphthoquinone) in oil and 5 grains (0.32 Gm.) of bile salts orally three times daily. The following day the prothrombin level was 26.6 per cent. Medication was increased to 2 mg. of menadione and 5 grains (0.32 Gm.) of bile salts three times daily. The following morning the prothrombin level was 24 per cent. The patient was operated on on the same day. The surgeon observed the liver to be lying well up under the right costal margin; the head of the pancreas seemed normal, and a diagnosis of probable carcinoma of the common bile duct was made. A cholecystogastrostomy was done. Bleeding was not excessive during the operation. The patient was returned to her room apparently in good condition with a pulse rate of 72 and blood pressure of 119 systolic and 50 diastolic. The dressings two hours later were saturated with bright red blood. The postoperative course was steadily downhill, and the patient died eleven hours after the operation.

Postmortem examination revealed the abdominal cavity filled with dark blood. The liver was estimated at one half to two thirds of its normal weight. (Permission to remove the organs was not obtained.) The microscopic picture was that of subacute yellow atrophy with the normal structure of the liver entirely absent (fig. 1). In a few areas there were remnants of lobules, but in most places there were only small groups of hepatic cords. The biliary tract was not obstructed.

Case 2.—A. C., a 56 year old white woman, was admitted to the Presbyterian Hospital on Sept. 7, 1940 with a history of slowly deepening jaundice for four weeks, itching of the skin, feeling of fulness in the epigastrium, belching, bloating and passage of flatus, loss of appetite and loss of 12 pounds (5.4 Kg.) in weight over a period of two months. It was her first attack of jaundice. She had never had gallbladder colic, chills or fever. Her stools had become light tan. She had had the usual diseases of childhood. Tonsillectomy had been done two years before the present illness. She had one son living and well; there had been no other pregnancies. Her mother died at 78 years of heart trouble and her father at 73 of kidney disease.

Physical examination revealed a moderately well developed, poorly nourished white woman of 56, weighing 116¾ pounds (53 Kg.). The skin and scleras were deeply jaundiced. Her pulse rate ranged from 65 to 90; her temperature was normal most of the time, occasionally reaching as high as 100.6 F., and her blood pressure measured 116 systolic and 78 diastolic. The liver was not palpable; and no abdominal masses were made out. The hemoglobin measured 65 per cent of normal; red blood cells numbered 3,330,000 and white blood cells 4,300 per cubic

millimeter. The urine showed 10 white blood cells per cubic millimeter of uncentrifuged specimen and was darkly stained with bile. Urobilinogen was present. Stools were for the most part clay colored; occasionally a tan-colored specimen was obtained. The benzidine reaction was positive, varying between 2 and 4 plus; some of the specimens showed neutral fats and numerous fatty acid crystals. The mercury bichloride test was negative for bile. No amebas or cysts were found on direct examination of the stools or on culture. Fluoroscopy revealed a normal outline of the stomach and duodenum. The blood Wassermann reaction was negative. The icterus index at the time of the patient's admission was 182; the direct van den Bergh test showed an immediate positive reaction. The blood cholesterol measured 213 mg., the esters 53 mg. and the total nonprotein nitrogen 26 mg. per hundred cubic centimeters. Albumin in the blood amounted to 2.79 and

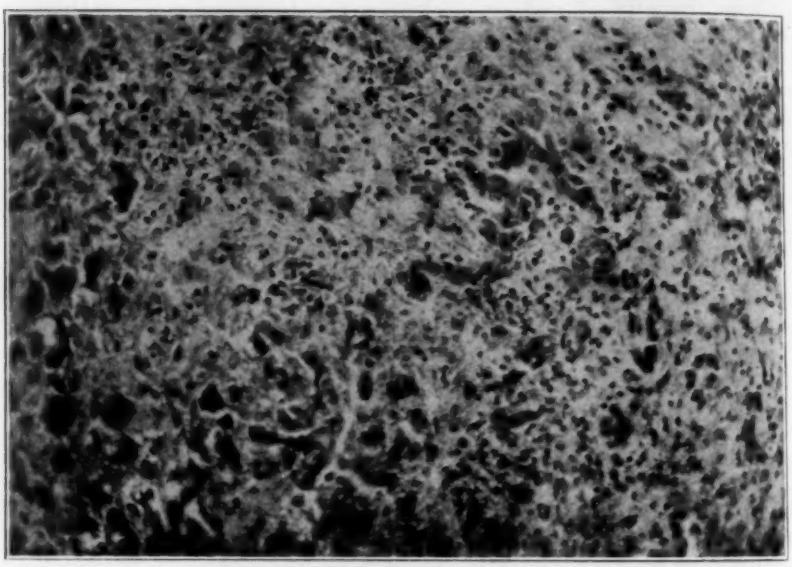


Fig. 1.—Photomicrograph of the liver of the patient in case 1, showing subacute yellow atrophy with the normal structure of the liver entirely absent.

globulin to 4.44 mg. Blood amylase was 157 units (normal, 200 units). The icterus index seventeen days after the original estimation was 211. Forty per cent of the gallbladder dye given intravenously was retained in the blood stream at the end of thirty minutes and 20 per cent at the end of sixty minutes. There was no evidence of gallbladder filling or of stone on the roentgen flat plate of the abdomen. The hippuric acid test for liver function showed excretion of 0.72 Gm., 24 per cent of normal. The prothrombin level four days after admission was 13.6 per cent.

The patient was given liver concentrate, vitamin C, the vitamin B complex and iron by mouth. She received also 100 mg. of nicotinic acid amide[7] intramuscularly every day. After the original determination of prothrombin the patient was

7. The nicotinic acid amide was supplied by the Abbott Laboratories.

given 2 mg. of menadione intravenously. This was repeated the following day. From this point she was given 1 mg. of crystalline menadione and 5 grains (0.32 Gm.) of a preparation of iron and bile salts[8] three times daily by mouth and frequent 2 mg. doses of the former intravenously.

Her prothrombin level went to 21.4 per cent the day after the original determination and climbed slowly until after six days of therapy it had reached 47.3 per cent. The patient had improved subjectively up to this time, but from this point she declined rapidly. Her prothrombin dropped slowly and steadily, even with large amounts of vitamin K and bile salts, and twenty days after the original determination it was 31.9 per cent (table 2). The patient's clinical picture was that of obstructive jaundice on the basis of a carcinoma of the head of the pancreas, common bile duct or papilla of Vater, the persistent blood in the stools strongly indicating the last named. On the evidence of the low prothrombin level and the poor response to vitamin K a diagnosis of a pathologic condition primary in the liver, possibly subacute yellow atrophy, was made, and the patient was not

TABLE 2.—*Prothrombin Fluctuations*

Case 1		Case 2		Case 3	
Date	Prothrombin (Per Cent of Normal)	Date	Prothrombin (Per Cent of Normal)	Date	Prothrombin (Per Cent of Normal)
November 15...	26.8	September 11...	13.6	June 11.....	36.7
16...	26.6	12...	21.5	12.....	36.8
17...	24.0	13...	27.8	13.....	36.4
		16...	33.0	14.....	35.4
		17...	42.0	17.....	43.7
		18...	45.9	18.....	50.7
		19...	47.3	19.....	51.9
		20...	45.6	20.....	60.4
		23...	40.6	21.....	64.0
		24...	34.6	24.....	74.8
		25...	33.7	25.....	82.2
		26...	32.7	26.....	86.0
		27...	34.5	27.....	90.5
		30...	38.2	28.....	90.5
		October 1...	31.9	July 1.....	96.2
				5.....	100.2

subjected to exploratory operation. Eighteen days after admission a mass about 6 by 6 cm. was palpable in the epigastrium 2 fingerbreadths below the ensiform cartilage. The liver was never felt at the right costal margin. In the last days of the patient's life subcutaneous hemorrhages appeared over most of her body. Her condition grew steadily worse, and she died twenty-five days after admission.

Postmortem examination revealed subacute yellow atrophy of the liver with recent pancreatitis and fat necrosis of the peripancreatic adipose tissue. The bile ducts were unobstructed. The liver weighed 945 Gm. On the surface of the right lobe there were coarse depressions, 3 to 4 mm. in depth, involving all of the superior surface and about 50 per cent of the lower surface (fig. 2). Sections made through this lobe revealed disseminated reddish brown regions where the hepatic lobules were inconspicuous (fig. 3). The surface of the left lobe was fairly smooth, there being only slight depressions where the lobules had disappeared. In the surface appearing when this lobe was cut, most of the lobules were still present. Microscopic sections showed a retention of about 75 per cent of the lobules in this lobe, but in the right lobe most of the hepatic cords had disappeared, and the stroma had collapsed (fig. 4).

8. The preparation was bilron, furnished by Eli Lilly & Co.

The pancreas showed disseminated regions of necrosis with infiltration of polymorphonuclear leukocytes, plasma cells and macrophages in the interstitial tissue. Between the regions of necrosis the acinous structure was fairly well maintained.

Fig. 2.—The liver of the patient in case 2. Note the coarse depressions on the surface of the right lobe and the much shallower ones on the left.

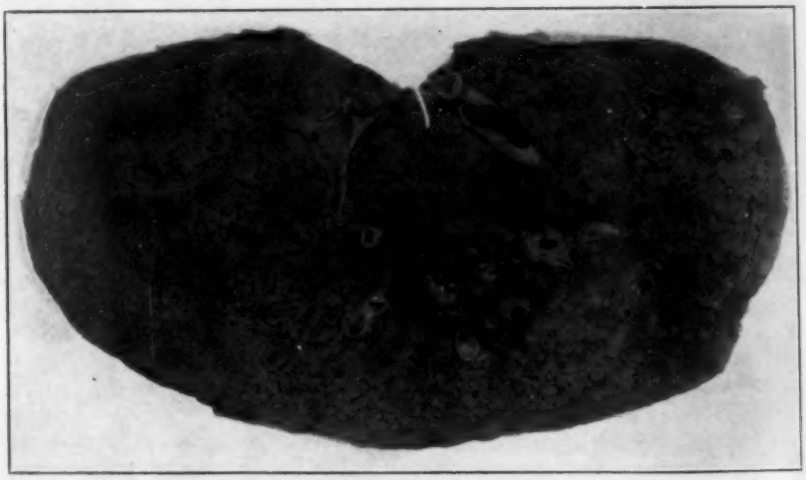


Fig. 3.—Section through the liver of the patient in case 2. The normal hepatic lobules are inconspicuous.

The relatively normal hepatic structure remaining in the left lobe may have accounted for the initial rise in prothrombin from 21.4 to 47.3 per cent. In case 1 there were no unchanged regions in the liver, and in only a few instances were

there remnants of lobules. In the three days on which the prothrombin level was taken in case 1, there was no response to vitamin K therapy.

CASE 3.—J. C., a 31 year old white woman, was admitted to the Presbyterian Hospital June 10, 1940, complaining of anorexia, nausea, weakness and dull pain in the epigastrium for one week. Four days before admission a slowly deepening jaundice was first noticed. At the time this was first apparent, she noticed swelling of her hands and wrists; this persisted for three days. She had been perfectly well until the onset of symptoms and had had no similar attack in the past. There had been no gallbladder colic, chills or fever. No history of her having taken drugs could be elicited. She stated her stools had been light in color during the two days prior to admission. Her mother died of diabetes; her father, of

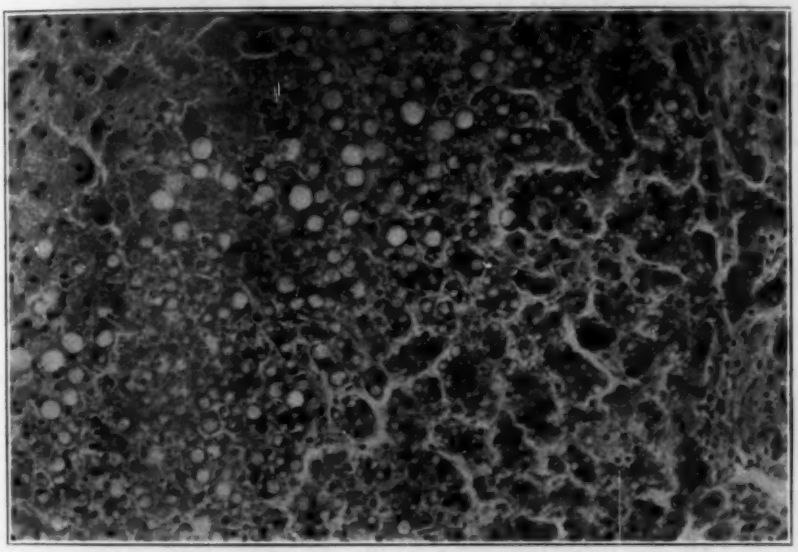


Fig. 4.—Microscopic picture from the right lobe of the liver of the patient in case 2. Most of the hepatic lobules have disappeared, and the stroma has collapsed. Note the deposits of fat.

"Bright's disease." She had had an appendectomy at the age of 12, a thyroidectomy at 21 and a tonsillectomy at 25.

Physical examination revealed a well developed and well nourished white woman deeply jaundiced. Neither her liver nor her gallbladder were palpable. Her blood pressure measured 125 systolic and 70 diastolic. Scars of her appendectomy and thyroidectomy were present. Physical examination disclosed nothing else of significance. The hemoglobin measured 83 per cent, the red blood cell count was 5,100,000 and the white blood cell count 6,100. Her urine contained bile (3 plus), no urobilinogen and no leucine or tyrosine crystals. An Ewald test meal showed 12 points of free acid and 16 points of total acids. The stools were gray with a questionable positive test for bile, were free of occult blood and contained a moderate amount of fat. No amebas were found on direct smear or culture. The icterus index at the time of the patient's admission was 107. A cholecystogram

revealed a nonfilling gallbladder. The rose bengal test for liver function showed complete retention of the dye at ten and eighteen minutes. Her excretion of hippuric acid expressed as benzoic acid was 0.268 Gm., 8.9 per cent of normal. The prothrombin level on the day following the patient's admission to the hospital was 36.7 per cent.

A 2 mg. dose of menadione was given intravenously on the second and third days after admission and from this point she received 0.6 mg. of the same material and 5 grains (0.32 Gm.) of an iron-bile salt preparation [8] by mouth three times daily during the remainder of her stay at the hospital. She also received from this point 5 mg. of the vitamin B complex three times daily by mouth and 100 mg. of nicotinic acid intramuscularly. Her subsequent prothrombin levels are recorded in table 2. During the first four days she showed little change. Beginning the fifth day there was a slow steady rise in the prothrombin level until on the twenty-fifth day after her admission it was 100.2 per cent.

Her symptoms increased in severity after hospitalization, the nausea going into rather violent attacks of vomiting. About five days after admission her clinical condition began to improve, and this improvement continued until she was discharged June 29, feeling quite well. A rose bengal test for liver function on June 26 showed a 91 per cent retention of the dye at ten minutes and 71 per cent at eighteen minutes. On July 5 these readings were 76.6 and 58.2 per cent. The hippuric acid synthesis and excretion on June 25 was 0.571 Gm. (19.1 per cent) and on July 5 was 1.035 Gm. (33 per cent of normal). These tests did not give normal results as soon as did tests for the prothrombin level.

COMMENT

The patients in cases 1 and 2 and the patient in case 3 for the first five days of her hospital stay showed similarity in their prothrombin levels and in their response to vitamin K therapy. An exploratory operation was performed on the patient in case 1 for a probable carcinoma of the head of the pancreas. The patient in case 2 would ordinarily have been subjected to such an operation, but because of the similarity of prothrombin response in the 2 patients, surgical intervention was not carried out. In both cases postmortem examination revealed subacute yellow atrophy of the liver. The patient in case 2 would probably have succumbed to postoperative hemorrhage had she been subjected to operation.

The diagnosis in case 3 is questionable. Ordinarily, the patient's disease would have been considered catarrhal jaundice. Three cases of transitory silent jaundice in middle-aged patients have been studied. In the first there was no depression of the prothrombin. In the second the initial level was 57.6 per cent, and twenty-four hours after the patient received 1 mg. of menadione intravenously it came to 84 per cent. The other case showed a rise of from 39.7 to 73.8 per cent in three days. A diagnosis of catarrhal jaundice was made in each case. As mentioned before, in this study patients with obstructive jaundice from blocking of the common bile duct by tumor, stricture or stone have responded without exception to vitamin K therapy, most of them within twenty-

four hours after medication was started. Many patients with subacute yellow atrophy or similar severe damage of the liver do not recover, but some, like the patient in case 3, do. This patient, depending on her clinical course, might not have been subjected to operation, even without the prothrombin study, but patients falling in the group with those of cases 1 and 2 would have been operated on and possibly would have died immediately after operation.

Three cases are hardly enough on which to base definite conclusions, especially when autopsies were made in only 2. But the similarity of

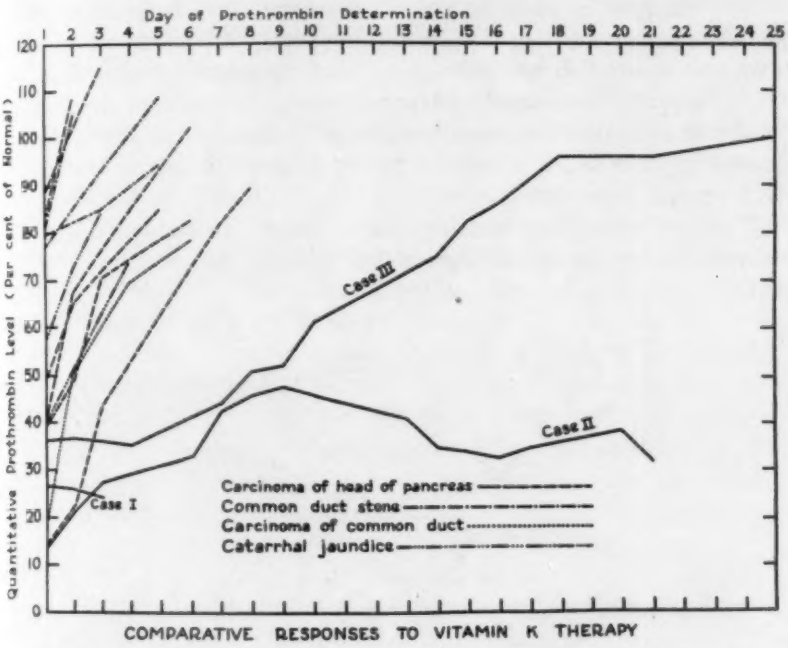

Day of Prothrombin Determination
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Quantitative Prothrombin Level (Per cent of Normal)
120 110 100 90 80 70 60 50 40 30 20 10 0
Case III
Case II
Case I
Carcinoma of head of pancreas
Common duct stone
Carcinoma of common duct
Catarrhal jaundice
COMPARATIVE RESPONSES TO VITAMIN K THERAPY

Fig. 5.—Comparative responses to vitamin K therapy in cases of obstruction of the common bile duct and cases of severe damage of the liver.

the prothrombin studies in the 3, combined with the severe damage of the liver in the 2 instances in which autopsies were made, definitely influences the procedure in cases of silent jaundice. Any patients who do not show a good and fairly prompt plasma prothrombin response to vitamin K therapy are not subjected to operation until the proper response occurs. Some of these patients will never show this response and will go on to death. However, they will have been spared the unnecessary expense and distress of a major surgical procedure. Others under medical management may recover. If they are subjected to oper-

ation, the severe damage to the liver may result in death from shock, postoperative hemorrhage or both.

It may be that with careful consideration of the history and physical findings and a study of the patient's response to vitamin K therapy, the two stage prothrombin determination will make possible a preoperative or premortal diagnosis in the majority of cases of subacute yellow atrophy of the liver.

SUMMARY

The two stage prothrombin determination as a measure of a patient's response to vitamin K therapy is a delicate test for liver function.

It offers promise of being a means of accurately distinguishing before operation between obstruction of the common duct from tumor or silent stone and severe damage of the liver, such as subacute yellow atrophy, which may clinically simulate obstruction of the common duct. Thus unnecessary surgical intervention and possible fatal postoperative hemorrhage may be avoided. Some of these patients with severe damage of the liver may recover.

The procedure described may be a means of making an accurate preoperative or premortal diagnosis of subacute yellow atrophy of the liver.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1940

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

(Continued from page 540)

VII. INFANTILE PARALYSIS

General Considerations.—Members of the medical profession and laymen as well are becoming more interested in poliomyelitis owing to the interest of many lay organizations and to the activities of the National Foundation for Infantile Paralysis, such as grants in aid of research work, publications, special training of nurses and physical therapeutists and establishment of research fellowships for physicians.

During 1940 confirmation of the transmission of poliomyelitis to animals other than man and the monkey has been reported, and evidence demonstrating the alimentary tract as a pathway of entrance of the virus and spread of the disease has been adduced. Discussion of the use of hot moist applications during the acute stage of the disease has been reopened. There is an increasing trend of thought away from absolute, continuous, rigid immobilization of joints. Indirect laboratory evidence that a disease caused by a neurotropic virus can be successfully treated by serum is derived by Zichis and Shaughnessy [208] from their work on equine encephalomyelitis. No further evidence has been reported to confirm the value of convalescent serum as a specific therapeutic agent.

Causation.—Aycock [209] states that there is epidemiologic evidence that the virus of poliomyelitis is widespread but that the occurrence of the paralytic disease in those exposed to the virus is limited and selective. Some of the selectivities indicate that the determining factor between clinical and subclinical poliomyelitis resides in the host. A familial tendency suggests that this factor is inherent; seasonal and geographic selectivities indicate a physiologic rather than an anatomic character; association with a certain constitutional type points to an endocrine dysfunction; and the suspected selectivity seen in the occurrence of poliomyelitis during pregnancy, in view of the implication of the nasal mucosa as the portal of entry of the virus, suggests that estrogenic substances are concerned. Two series of experiments are described. In the first series the injection of estrogenic substance into castrated immature female monkeys enhanced their resistance to the intranasal instillation of the virus. In the second series there was studied a small number of

208. Zichis, J., and Shaughnessy, H. J.: Experimental Western Equine Encephalomyelitis: Successful Treatment with Hyperimmune Rabbit Serum, J. A. M. A. **115**:1071-1078 (Sept. 28) 1940.

209. Aycock, W. L.: Subclinical Endocrinology as a Factor in Autarceologic Susceptibility to Poliomyelitis, Endocrinology **27**:49-57 (July) 1940.

comparative estrogen assays of the urine of patients with poliomyelitis and that of normal persons. The results indicate a higher average excretion of estrogenic substance in the group of patients with poliomyelitis. These observations suggest that an autarcetic susceptibility to poliomyelitis may lie in some disturbance in the economy of estrogenic substance. [ED. NOTE: These are interesting observations, which may lead to definite conclusions with more confirmatory evidence.]

Trask, Paul and Vignec [210] state that the appearance of the poliomyelitis virus in the stools of patients with poliomyelitis seems to be characteristic of many strains. The virus is capable of prolonged activity in stools of human beings and is stable in this medium. The virus can be demonstrated in the stools of patients with paralytic or abortive poliomyelitis and in those of convalescent patients.

Paul, Trask, and Gard [211] report that in two of three large urban epidemics of poliomyelitis the virus of the disease has been detected in samples of sewage. In sewage from one of the sites it was found repeatedly. Both sites from which the virus-containing samples were obtained were in the vicinity of isolation hospitals. The authors believe that the findings indicate that this virus can be transported, for short distances at least, through the medium of flowing sewage. [ED. NOTE: This is one of the most important basic considerations in the whole poliomyelitis problem which has been reported in recent years.]

Pathologic Characteristics.—Sabin [212] reports that examination of the olfactory bulbs by serial sections from human beings with poliomyelitis does not reveal the pathologic changes which have been observed in the olfactory bulbs of monkeys succumbing after nasal instillation of the virus. No virus was found in olfactory bulbs from 5 patients in whom the virus was isolated from other tissues. This is strong evidence against the theory that the olfactory pathway is the usual portal of entry of the virus in man. [ED. NOTE: From this evidence and his other experimental work Sabin believes that the alimentary tract is one of the main portals of entry of the virus.]

Experimental Poliomyelitis.—Lillie and Armstrong [213] report that intracerebral inoculation of cotton rats and white mice with the Lansing strain of poliomyelitis virus produces an inflammatory process char-

210. Trask, J. D.; Paul, J. R., and Vignec, A. J.: Poliomyelitis Virus in Human Stools, J. Exper. Med. **71**:751-763 (June) 1940.

211. Paul, J. R.; Trask, J. D., and Gard, S.: Poliomyelitis Virus in Urban Sewage, J. Exper. Med. **71**:765-777 (June) 1940.

212. Sabin, A. B.: Olfactory Bulbs in Human Poliomyelitis, Am. J. Dis. Child. **60**:1313-1318 (Dec.) 1940.

213. Lillie, R. D., and Armstrong, C.: Cerebrospinal Pathology of Experimental Poliomyelitis in Eastern Cotton Rat, Sigmodon Hispidus Hispidus, and in White Mouse, Mus Musculus, Pub. Health Rep. **55**:718-725 (April 26) 1940.

acterized by necrosis of nerve cells, exudation of polymorphonuclear leukocytes and invasion of necrotic cells, neuronophagia by macrophages, diffuse and focal cellular gliosis, vascular endotheliosis and lymphocyte infiltration of the perivascular sheath. In the brain the dorsal portion of the pons shows the greatest involvement: then the medulla, the midbrain, the thalamus and the nuclei of the cerebellar roof. The cerebral cortex in both species shows relatively little involvement, mostly in the hippocampus. The corpora striata and cerebellar cortex show the least involvement. Despite intracerebral inoculation into the thalamomesencephalic region the earliest observed lesions are found in the spinal cord in both species. The process is considered closely analogous to the reaction of poliomyelitis in man and in the monkey. In general the amount of lymphocyte infiltration of the perivascular sheath is less in cotton rats than in mice, monkeys or human beings. [ED. NOTE: This is an excellent article and certainly a real contribution to the subject.]

Armstrong [214] has accomplished thirteen successive transfers of the virus to white mice. The virus has a tendency to affect a higher proportion of mice in the later transfers. The incubation period is still variable, ranging from two to twenty days, but in the majority of the mice paralysis develops in from three to seven days. Death is now the rule in one to three days from the onset of the symptoms. In the absence of respiratory involvement, the mice attempt to eat, appear sleek and are often without symptoms other than the paralysis. The pathologic lesions in cotton rats and in mice as far as studied are similar in type to those observed in poliomyelitis in other experimental animals and in men. [ED. NOTE: This is another important experimental contribution.]

Peers [215] briefly describes the lesions produced in 11 monkeys by the Lansing strain of poliomyelitis virus before transfer to the cotton rat.

> After transfer and during its propagation in rats the virus has been reinoculated into 4 monkeys. In these it produced uniform lesions morphologically indistinguishable from those observed before rat passage. It therefore appears that neither the initial transfer nor the subsequent passage through 33 cotton rats visibly modified the pathogenic properties of this strain of poliomyelitis virus.

Toomey [216] produced paresis of the muscles about the fetlock joints and hoofs of the hindlegs of a horse after injections of fortified virus. Steppage gait developed, and the animal later had difficulty in walking. Its condition gradually became worse, and finally the muscles of the

214. Armstrong, C.: Studies on Choriomeningitis and Poliomyelitis (James M. Anders Lecture), Tr. & Stud., Coll. Physicians, Philadelphia **8**:1-11 (April) 1940.

215. Peers, J. H.: Note on Pathology in Monkeys of Lansing Strain of Poliomyelitis Virus Before and After Passage in Cotton Rat, Pub. Health Rep. **55**:726-727 (April 26) 1940.

216. Toomey, J. A.: Experimental Poliomyelitis in Animals Other Than the Monkey: Review of Literature, J. Pediat. **16**:519-527 (April) 1940.

hindlegs as well as those of the hoofs were involved. There was difficulty in rising, and its legs spread apart when it was placed on its feet. These experiments suggest to the author the following questions: Can the lower animals harbor the virus? Can they serve as carriers of the infection? Is the disease produced in them different from that occurring in man and in the monkey? Why are the smaller animals more resistant to the disease?

Toomey's [217] experiments with injections of poliomyelitis virus into the adrenal glands of monkeys lend support to the belief (1) that ordinarily the virus does not spread along well myelinated nerves of healthy Macaca mulatta monkeys and (2) that the virus will spread along the nerves of monkeys deficient in vitamin D if the virus is simply placed in contact with postganglionic fibers. The presumption is that in the latter animals the preganglionic medullated nerve fibers to the adrenal gland are made deficient and hence more susceptible.

Schultz [218] gives the results of his experiments with chemical agents in the prevention and treatment of experimental poliomyelitis. He states that

> artificially induced acceleration of the metabolism, the administration of such substances as vitamin B, viosterol and antuitrin S [chorionic gonadotropin]; of sulfanilamide, sodium sulfanilsulfanilate and sulfapyridine; also of several medicinal dyestuffs, used for their possible modifying action on the nervous pathways, all have failed to exercise any discernible therapeutic effect though the treatments were started a day or two after the inoculation of the animals and were continued until paralysis appeared.

[ED. NOTE: These are interesting observations, which should be borne in mind in treating the disease in its acute stage, but do not confirm the clinical observations of Rhett.[219]]

Examination.—Lowman [220] describes the tests used in his clinic for testing muscle groups. His conclusions are as follows:

> These methods of recording muscle group strengths are time-saving in a busy clinic, as the surgeon can quickly determine the imbalances and can quickly visualize joint function and control, which is what he is most concerned with in mapping his plan for reconstructive surgery. Clinically they are sufficiently accurate to meet the needs of the medical attendant and technicians. Every person using these scales can obtain about the same picture of the patient's condition. Uncertainties in the minds of everyone involved are minimized because no two persons can properly and equally evaluate all the complex muscle actions which take place mainly by groups. In

---

217. Toomey, J. A.: Absorption of Poliomyelitis Virus by Possibly Deficiently Medullated Nerves, Am. J. Dis. Child. **60**:548-551 (Sept.) 1940.

218. Schultz, E. W.: Chemical Agents in Prevention and Treatment of Experimental Poliomyelitis, Am. J. Pub. Health **30**:175-179 (Feb.) 1940.

219. Rhett, W. M.: Prophylaxis and Treatment of Poliomyelitis with Neoprontosil, J. Pediat. **16**:326-336 (March) 1940.

220. Lowman, C. L.: Muscle Strength Testing, Physiotherapy Rev. **20**:69-71 (March-April) 1940.

checking the whole body there are about 105 items if separate muscles are graded, whereas the chart for the above check has about 50, so that saving in time in making the check is also worth consideration.

[ED. NOTE: This is a good article and should be read by every one treating these conditions. It would be most advisable and helpful to all if some uniform system of muscle testing and recording could be adopted.]

Treatment.—Rhett [219] states that there is no way of making a diagnosis of poliomyelitis in the absence of involvement of the central nervous system. In an attempt to determine the value of azosulfamide (disodium 4-sulfamidophenyl-2′-azo-7′-acetylamino-1′-hydroxynaphthalene-3′,6′-disulfonate) as a prophylactic and therapeutic agent in clinical poliomyelitis, it was given to 440 acutely ill children during an epidemic in an approximate dose of 1 grain (0.06 Gm.) per pound (0.45 Kg.) of body weight per day. In this series paralysis developed in 1 child; this occurred when the dose was reduced below the maintenance level. The paralysis subsided completely in three weeks. Two children had meningeal symptoms when the dose was diminished below this same maintenance level, and these symptoms subsided when the full dose was given again. Eleven additional patients with paralytic involvement were treated during the same period. Toxic symptoms subsided within twenty-four to forty-eight hours, and there was no apparent advance in paralytic involvement after the doses reached adequate amounts and were maintained for twenty-four to forty-eight hours. Rhett states: "It is difficult to avoid the feeling that the drug is clinically effective in inhibiting the virus of poliomyelitis." [ED. NOTE: Grants have been made by the National Foundation of Infantile Paralysis to evaluate the effect on poliomyelitis of the various chemotherapeutic agents, including sulfanilamide and its derivatives. No favorable reports on the value of these agents have as yet been made.]

Thenebe and Hirshberg [221] report their experiences with 27 consecutive patients with preparalytic infantile paralysis (36.4 per cent of the total patients admitted) treated with nonspecific protein (sterile milk given intramuscularly), 50 per cent sucrose solution given intravenously and dehydration (restricted intake). There was no paralysis or death in this group. In 1 case weakness developed, which subsequently disappeared entirely before the patient was discharged from the hospital.

Operative Treatment.—King [222] reports:

One hundred and six ankle fusions were done in a five year period (1934 to 1938 inclusive) on patients with residual anterior poliomyelitis at the New York

221. Thenebe, C. L., and Hirshberg, M. S.: Further Studies in Therapy of Acute Anterior Poliomyelitis, Connecticut M. J. **4**:25-27 (Jan.) 1940.

222. King, B. B.: Ankle Fusion for Correction of Paralytic Drop Foot and Calcaneus Deformities, Arch. Surg. **40**:90-97 (Jan.) 1940.

Orthopaedic Dispensary and Hospital. Of these, 72 were done for paralytic drop foot and 34 for paralytic calcaneus deformities. The patients have been carefully followed, the follow-up period ranging from seven months to five and one-half years. In 85 cases (80 per cent) the end result was good. In 10 (9 per cent) the end result was only fair, there being either too much or too little equinus. In 5 (5 per cent) the end result was good so far as the ankle was concerned but an associated unstable knee was not rendered stable. In 6 (6 per cent) the end result was good so far as the ankle was concerned but an associated lateral instability of the foot needed further operative stabilization of the subtalar and midtarsal joints. In no case were the results considered poor. Of 32 unstable knees, 27 (84 per cent) were stabilized by ankle fusion. There was no resulting interference with growth in any case. Functional use of the involved extremity was improved in all cases. In 4 cases (4 per cent) pseudarthrosis developed, but in all 4 of these the joint became solidly arthrodesed after refusion.

Ankle fusion is a satisfactory method of treating drop foot and calcaneus deformities regardless of the cause. It results in freedom from disability caused by deformity, pain or instability. In a fused ankle there is no pain, body impingement or swelling such as occurs at times after bone block operations. The operative procedure is relatively simple in contrast to such methods as the Lambrinudi operation and its modifications. An additional advantage is that associated instability of the knee can often be corrected by ankle fusion. The end results are uniformly satisfactory as indicated by this five year study of 106 cases.

It is important to avoid injury to the epiphysial cartilages of the distal ends of the tibia and fibula if they are still present. The end result is determined by the degree of equinus obtained. Five degrees to 10 degrees of equinus for males, and 10 to 15 degrees of equinus for females is in general satisfactory.

[ED. NOTE: This is a carefully prepared report of a procedure which we believe is not performed in many clinics for either a paralytic calcaneus or drop foot.]

For tibial torsion following deformities of the foot resulting from poliomyelitis and requiring osteotomy for correction, O'Donoghue [223] performs a Z osteotomy and in addition removes a triangular wedge longitudinally to obtain correction. [ED. NOTE: Technically this looks good. However, is not a simple osteotomy all that is necessary to correct this deformity?]

VIII. NEUROMUSCULAR DISORDERS, EXCLUSIVE OF INFANTILE PARALYSIS

General Considerations.—Under the heading of neuromuscular disorders are grouped the many types of degenerative changes in the neuromuscular system: dystrophy, muscular atrophy, amyotonia, myasthenia and like conditions. Terminology presents a great difficulty. So many apparently different entities having at the same time so many

223. O'Donoghue, D. H.: Controlled Rotation Osteotomy of Tibia, South. M. J. **33**:1145-1149 (Nov.) 1940.

common characteristics are included that it is extremely confusing to try to develop a satisfactory classification for use in a review of the literature.

Pseudohypertrophic Muscular Dystrophy.—There has been great interest in the use of vitamin therapy to bring about a slowing down at least of the progress of pseudohypertrophic muscular dystrophy. A nonspecific nutritional muscular dystrophy has been produced in rabbits by a diet deficient in vitamin E, and Mackenzie and McCollum [224] describe the cure of this condition by the use of synthetic vitamin E in the form of alpha tocopherol. This compound has been subjected to extensive investigation in the last year by a number of the better pharmaceutic concerns. It has the advantage over wheat germ oil that it can be more definitely standardized as to dosage. Encouraging results were obtained by Bicknell,[225] and work similar to that of Mackenzie and McCollum [224] was carried out by Shimotori [226] with satisfactory results in guinea pigs. On the other hand, Antopol and Schotland [227] treated pseudohypertrophic muscular dystrophy with vitamin B_6 (pyridoxine) and obtained some control over the condition. Donovan [228] combined the use of the vitamin B complex and vitamin E and also gained satisfactory results.

It appears from the literature that the particular constituent of the vitamin B complex which is helpful in treating these conditions is vitamin B_6 (given in the form of pyridoxine hydrochloride) and that the use of this compound in connection with the tocopherols, whether alpha tocopherol alone or a combination of alpha, beta and gamma tocopherol, produces the results. It is believed by many that both vitamin B_6 and vitamin E are necessary and that neither alone is entirely effective.

Hypertrophic Muscular Dystrophy (Hypertrophia Musculorum Vera).—Hypertrophic muscular dystrophy appears in adults and is not common; it is believed to be in some way associated with thyroid

224. Mackenzie, C. G., and McCollum, E. V.: Cure of Nutritional Muscular Dystrophy in Rabbit by Alpha-tocopherol and Its Effect on Creatine Metabolism, J. Nutrition **19**:345-362 (April) 1940.

225. Bicknell, F.: Vitamine E in Treatment of Muscular Dystrophies and Nervous Diseases, Lancet **1**:10-13 (Jan. 6) 1940.

226. Shimotori, N.; Emerson, G. A., and Evans, H. M.: Prevention of Nutritional Muscular Dystrophy in Guinea Pigs with Vitamine E, J. Nutrition **19**:547-554 (June) 1940.

227. Antopol, W., and Schotland, C. E.: Use of Vitamin B_6 in Pseudohypertrophic Muscular Dystrophy, J. A. M. A. **114**:1058-1059 (March 23) 1940.

228. Donovan, G. E.: Lordosis and Muscular Dystrophy, Lancet **2**:162-163 (Aug. 10) 1940.

insufficiency. Hesser [229] has reported a case in which this condition was associated with hypothyroidism. Mollaret and Sigwald [230] point out the relation between acquired generalized muscular hypertrophy and thyroid insufficiency. The latter would suggest a glandular relation to muscular hypertrophy as differentiated from pseudohypertrophy which apparently may be associated with vitamin deficiency.

Progressive Muscular Atrophy.—There is little in the literature concerning progressive muscular atrophy other than that in certain instances it may be in some way congenital. There is no proof of any hereditary factor, but the report by Ruggeri [231] of muscular atrophy with other changes in 2 brothers and a sister is interesting, since in this instance the condition does not appear to be sex linked.

Amyotrophic Lateral Sclerosis.—Hassin [232] points out that amyotrophic lateral sclerosis is usually not difficult to diagnose. However, he shows that there are often cases in which a number of the ordinary clinical manifestations are lacking. In these cases incorrect diagnosis is frequent, since the picture may suggest other diseases. However, in his cases pathologic study proved the nature of the disease. In 1 of the cases the clinical picture was suggestive of spastic paraplegia of the Charcot-Erb type. He points out that there may be loss of tendon reflexes in the presence of a degenerative pyramidal tract. This of course is true. The loss of tendon reflexes sometimes occurs with other conditions in which there is degeneration of the pyramidal tract, such as certain types of cerebral spastic paralysis due to other causes.

Wechsler [233] reports a recovery obtained by treatment with the tocopherols (vitamin E).

Myasthenia Gravis.—In reviewing the literature on myasthenia gravis, Levy [234] indicates the many possible causes. According to Fraser

229. Hesser, F. H.: Hypertrophia Musculorum Vera (Dystrophia Musculorum Hyperplastica) Associated with Hypothyroidism: Case Study, Bull. Johns Hopkins Hosp. **66**:353-377 (June) 1940.

230. Mollaret, P., and Sigwald, J.: Acquired Generalized Muscular Hypertrophy and Thyroid Insufficiency in Adult with Report of Case, Gaz. méd. de France **47**:165-168 (April 1) 1940.

231. Ruggeri, R.: Acromicria and Muscular Atrophy in Two Brothers and Sister with Cleidocranial Dysostosis, Endocrinol. e pat. costit. **15**:52-65 (Feb.) 1940.

232. Hassin, G. B.: Amyotrophic Lateral Sclerosis: Anatomic and Pathologic Considerations, Arch. Neurol. & Psychiat. **43**:765-777 (April) 1940.

233. Wechsler, I. S.: Recovery in Amyotrophic Lateral Sclerosis Treated with Tocopherols (Vitamin E): Preliminary Report, J. A. M. A. **114**:948-950 (March 16) 1940.

234. Levy, M. L.: Symposium on Neuropsychiatry: Myasthenia Gravis, Med. Rec. **151**:269-273 (April 17) 1940.

and Pritchard,[234a] the preponderance of evidence favors the curare-like poisoning hypothesis. Disturbance of the creatine-creatinine relation similar to the metabolic upset in muscular dystrophy was believed by some observers to be a factor. While it can be stated that the myoneural junctions are certainly involved, they are probably not the only site of physiologic disturbance in the neuromotor system.

The use of prostigmine followed by the administration of aminoacetic acid and ephedrine has proved satisfactory. It is recommended that the simultaneous daily administration by mouth of aminoacetic acid and prostigmine methylsulfate be given further trial as standard therapy for patients with myasthenia gravis. Levy recommends the concurrent use of the drugs and advises the oral administration of 12 Gm. of aminoacetic acid and 30 to 60 mg. of prostigmine methylsulfate per day. Scannell [235] presents substantiating evidence for the use of these drugs. In a paper by Morgan and Williams [236] myasthenia (though not myasthenia gravis) is discussed in its relation to thyrotoxicosis. Four cases were reported; in 2 the patients recovered after thyroidectomies. One patient died while being prepared for thyroidectomy, apparently from exhaustion of the muscles of respiration. The fourth case was too recent to report. The relation between myasthenia and thyrotoxicosis is also discussed by van Bogaert; [237] in the case he reports there was the still further complication of diabetes mellitus.

Dystonia Musculorum Deformans.—Lemere [238] discusses the quinine treatment of dystonia musculorum deformans. He believes that results from the use of quinine support the contention of Hassin [238a] that dystonia musculorum deformans is due to a disturbance of muscular tone and not to a central lesion. The case Lemere reports is that of a woman with dystonic motions chiefly in the neck; there was a remarkable response to the use of quinine up to the point of cinchonism.

[Ed. Note: The group of neuromotor conditions just discussed is variegated and represents several different entities; this is shown by the

---

234a. Fraser, F. R.: Transmission of Nervous Effects by Acetylcholine, Brit. M. J. **1**:1349-1354 (June 25) 1938. Pritchard, E. A. B.: Prostigmin in Myasthenia Gravis, Lancet **1**:432-434 (Feb. 23) 1935.

235. Scannell, R. C.: Myasthenia Gravis: Case with Necropsy, J. Iowa M. Soc. **30**:154-159 (April) 1940.

236. Morgan, H. J., and Williams, R. H.: Muscular Atrophy and Weakness in Thyrotoxicosis (Thyrotoxic Myopathy, Exophthalmic Ophthalmoplegia), South. M. J. **33**:261-269 (March) 1940.

237. van Bogaert, L.: Antagonism of Myasthenia Gravis and Thyrotoxicosis, Schweiz. med. Wchnschr. **70**:501-502 (June 8) 1940.

238. Lemere, F.: Quinine Treatment of Dystonia Musculorum, J. A. M. A. **114**:1068 (March 23) 1940.

238a. Hassin, G. B.: Quinine and Dystonia Musculorum Deformans, J. A. M. A. **113**:12 (July 1) 1939.

diversity of response to various forms of treatment. In some cases recovery was obtained by the use of vitamin therapy; in others, by glandular therapy; in still others by the use of prostigmine and aminoacetic acid, and in Lemere's case quinine seems to have been effective. There is room for considerable advance in the study of both the causation and the treatment of these conditions, but what is most needed is a basis for a more definite and accurate classification of the components of this rather heterogeneous group.]

Traumatic and Other Acutely Acquired Paralysis.—[ED. NOTE: At the present time, because of the greatly increased number of injuries, the literature on the treatment of traumatic paralysis is extensive. The subjects discussed are paralysis resulting from injuries from automobiles and airplanes and paralysis resulting from occupational conditions; the latter variety is complicated by hysteria and difficulties about compensation.]

Many reports deal with methods of nerve suture; among these the work of Dunn [239] in comparing various methods of nerve suture is of interest.

Forrester [240] makes a plea for the early suture of nerves. He also discusses detailed technics, describes common injuries of nerves and gives a number of case reports.

Paralysis of the serratus anterior muscle is discussed by Overpeck and Ghormley.[241] In their series of cases the causative agent was trauma in 82 per cent. Treatment was of two general types, conservative and operative. In the conservative type of treatment there was complete recovery in a number of instances. Of the operative types of treatment there were three general methods: (1) fixation of the scapula to the underlying ribs, (2) substitution of an adjacent subscapular nerve for the long thoracic and (3) use of transplants of the various muscles of the shoulder girdle.

McGoogan [242] reports 3 cases of isolated paralysis of the serratus anterior muscle during the puerperium. In all instances this occurred on the fourth day after delivery. The cause could possibly have been tilting of the head and neck while the patient was under the anesthesia,

---

239. Dunn, G. R.: Symposium on Fractures and Other Trauma: Peripheral Nerve Surgery, Minnesota Med. **23**:748-751 (Oct.) 1940.

240. Forrester, C. R. G.: Peripheral Nerve Injuries with Results of Early and Delayed Suture, Am. J. Surg. **47**:555-572 (March) 1940.

241. Overpeck, D. O., and Ghormley, R. K.: Paralysis of Serratus Magnus Muscle, Caused by Lesions of Long Thoracic Nerve, J. A. M. A. **114**:1994-1996 (May 18) 1940.

242. McGoogan, L. S.: Isolated Paralysis of Serratus Anterior Muscle During Puerperium, Am. J. Obst. & Gynec. **40**:313-315 (Aug.) 1940.

but McGoogan inclines more strongly to the view that it represented a deficiency of members of the vitamin B complex during the puerperium.

A complete, exhaustive and well illustrated report of traumatic lesions of the nerves of the wrist is made by Harmer.[243] [Ed. Note: This article is of great value and covers all phases of the diagnosis and the treatment of these conditions.] Munro and Wegner [244] and Stuck [245] discuss in considerable detail wounds and injuries with and without bone or nerve damage in the cervical region as well as in the lower part of the spinal cord.

Nerve Paralysis Due to Toxic Agents.—Rolleston [246] reports a case of hemiplegic paralysis following diphtheria. Valerio [247] reports 2 cases of brachial paralysis following the use of antigonococcic serum. Camaüer [248] reports paralysis of the left axillary nerve following the administration of antitetanic serum.

Holtzman and Howes [249] report destruction of peripheral nerves by the action of radium. In their case, paralysis came on during the course of reaction to irradiation. The latent period of one week between the application of the needles and the onset of paralysis eliminated any mechanical injury by the radium needles as a cause. The destruction of the nerve by neoplastic invasion could be ruled out by the disappearance of the nodule treated concomitantly with the onset of paralysis. The authors do not think that paralysis was the direct result of irradiation of the nerve tissue itself; they consider it rather the result of the formation of scar tissue. They feel that this secondary obliteration of the nerves should be anticipated and intensive therapy applied to the areas affected.

[Ed. Note: These cases serve to emphasize the occasional dangers to the nervous system from the use of serum and other toxic agents.]

---

243. Harmer, T. W.: Traumatic Lesions of Nerves of Wrist and Hand, Am. J. Surg. **47**:517-541 (Feb.) 1940.

244. Munro, D., and Wegner, W.: Bone Lesions Accompanying Cervical Spinal Cord Injuries: End Result Study of Seventy-Six Cases, New England J. Med. **222**:167-173 (Feb. 1) 1940.

245. Stuck, R. M.: Spinal Injuries with Nerve Damage, Southwestern Med. **24**:157-160 (May) 1940.

246. Rolleston, J. D.: Hemiplegia in Diphtheria, Clin. J. **69**:67-68 (March) 1940.

247. Valerio, A.: Two Cases of Postantigonococcic Serum Brachial Paralysis, Urol. & Cutan. Rev. **44**:294-295 (May) 1940.

248. Camaüer, A. F.: Paralysis (Inflammation of Left Circumflex Nerve) After Use of Tetanus Antitoxin: Case Report, Prensa méd. argent. **27**:548-550 (March 13) 1940.

249. Holtzman, I. N., and Howes, W. E.: Peripheral Nerve Destruction: Unusual Sequel of Radium Therapy, Am. J. Roentgenol. **43**:426-427 (March) 1940.

Tabes Dorsalis and Syringomyelia.—Soto-Hall and Haldeman [250] discuss neuropathic joint disease (Charcot joint). They say that the diagnosis of this disease rests on observation of a swollen, relaxed and disorganized joint, comparatively painless, in cases in which the usual signs of tabes dorsalis, syringomyelia or other involvement of the spinal cord are presented. The authors report 40 cases of various types of the disease and believe that the clinical evidence of rigid pupils and absence of knee jerks is of greater importance in the diagnosis of tabetic arthropathy than are tests of the blood and the spinal fluid. They feel that a culture of the synovial fluid should be made prior to any operative procedure on a Charcot joint.

McCauley [251] reports operative treatment of neurotrophic joints. He feels that when there is involvement of the spine operative fusion should be attempted in early stages, but that once extensive destruction has occurred this procedure is not advisable. He reports that support of the hip joint by means of braces is usually better than arthrodesis. The latter is more satisfactory in involvement of the various joints of the foot. It is important that routine periodic examinations be made of the lower extremities to discover the condition as early as possible so that arthrodesis may be successfully utilized.

Conley and Miller [252] report 5 cases of atrophic Charcot hip and conclude that this condition is not so uncommon as generally supposed. They believe the diagnosis should be suspected when there is increased mobility of the joint with a positive Wassermann reaction of the blood or spinal fluid. [ED. NOTE: A number of other cases of isolated Charcot joint have been reported during the year. Occurrence seems about evenly divided between unilateral and bilateral involvement.]

Cerebral Palsy.—Practically all the literature on cerebral palsy is devoted to statistical analysis, treatment and laboratory study of the various types. Making a statistical analysis, Phelps [253] reports approximately 68.8 per cent of a large series of patients as of essentially normal intelligence. This checks well with the school placement, since retardation of three grades in school represents approximately the retardation due to the handicap. He reports that in 57 per cent of the cases the cerebral palsy is quadriplegic; in 21 per cent, hemiplegic; in 11 per cent,

---

250. Soto-Hall, R., and Haldeman, K. O.: Diagnosis of Neuropathic Joint Disease (Charcot Joint): Analysis of Forty Cases, J. A. M. A. **114**:2076-2078 (May 25) 1940.

251. McCauley, J. C., Jr.: Operative Treatment of Neurotrophic Joints, Urol. & Cutan. Rev. **44**:592-594 (Sept.) 1940.

252. Conley, A. H., and Miller, D. S.: Atrophic Charcot Hips: Report of Five Cases, J. Bone & Joint Surg. **22**:638-644 (July) 1940.

253. Phelps, W. M.: Treatment of Cerebral Palsies, J. Bone & Joint Surg. **22**:1004-1012 (Oct.) 1940.

paraplegic; in the remainder, scattered in various combinations. The cases in which there is true spasticity represent 54 per cent of the total; athetosis is present in 40 per cent and ataxia in only 5 per cent. The incidence of the condition is entirely predictable, since the number of cases found per hundred thousand of population is the same for all the various areas of the country studied. Operation is limited to the truly spastic type and is not indicated for the athetoid. Sirkin [254] reports a critical analysis of five years' work with cerebral palsy in the New York State School, for mentally defective children, at Newark, New York. [ED. NOTE: This report is especially interesting in that all of these children, who are definitely of low intelligence, succeeded in making satisfactory physical progress and thereby became much less of a social problem to the institution.]

With regard to the various methods of treatment, the question of the use of curare is discussed by Burman.[255] He states that "curare is a variable mixture, so that it is difficult to get a curare of constant assay and constant action for use in dystonic and spastic states." He investigated two erythrina derivatives, erythroidine hydrochloride (an alkaloid extracted from Erythrina americana mill) and extract of Erythrina glauca, as well as a number of curare extracts. He observed in general that any preparation of curare after its intravenous injection exerted its effects first on the muscles supplied by the cranial nerves, then on skeletal muscles and lastly on the muscles of respiration. The initial symptom is invariably dizziness. As this recedes, the upper eyelids become heavy and may droop temporarily. Diplopia may be present. As these changes increase, the skeletal release begins to take place, resulting in cessation of athetosis, plastic rigidity or hypertonia. The effect is not long lasting; the patient returns to normal within twenty to thirty minutes. It is hoped that a safe curare of prolonged effect will be found, one which will be effective when orally administered.

Bennett [256] reports the use of curare in preventing traumatic complications in convulsive shock therapy. [ED. NOTE: This has no direct relation to cerebral palsy, but the results of this use of the drug could be studied to obtain greater familiarity with its effects.]

Pusitz, Lattimore, Gold and Ebendorf [257] also report biologic and chemical studies with the use of curare.

---

254. Sirkin, J.: Five Years Work with Cerebral Palsy: Critical Analysis, Psychiatric Quart. **14**:185-193 (Jan.) 1940.

255. Burman, M. S.: Clinical Experiences with Some Curare Preparations and Curare Substitutes, J. Pharmacol. & Exper. Therap. **69**:143-148 (June) 1940.

256. Bennett, A. E.: Preventing Traumatic Complications in Convulsive Shock Therapy by Curare, J. A. M. A. **114**:322-324 (Jan. 27) 1940.

257. Pusitz, M. E.; Lattimore, J. L.; Gold, J. L., and Ebendorf, H.: Biologic and Biochemical Studies of Curare: Preliminary Report, J. Kansas M. Soc. **41**: 374-379 (Sept.) 1940.

Stieda [258] discusses the question of the value for Little's disease of the Bulgarian treatment with belladonna. The treatment is of some value, but it seems probable that the effects obtained were on those patients in whom the condition was acquired rather than due to a birth injury or congenital. [ED. NOTE: It appears that the use of these various drugs brings about a release of latent abilities such as would be found in postencephalitic conditions.]

Neuromotor Research.—Carey [259] reports a study of the wave mechanics of smooth muscle action, which is discussed in a series of articles on this general subject. Experimental multiple reflections between intestinal ligatures transformed traveling micropressure waves in smooth muscle into stationary ones. This smooth structural wave change has the typical attribute of a longitudinal wave of compression. "The living matter of the cytoplasm of smooth muscle, therefore, seems to have two aspects, namely (1) colloidal particle and (2) the associated micropressure wave."

Rosenblueth and Cannon [260] describe conditions affecting the late stages of neuromuscular transmission in relation to certain conditioning factors. Administration of prostigmine has been found to change the relation between stage 4 (fatigue) and stage 5 (recovery while tetanic stimulation is continued). Although curare has a prompt depressive influence in stage 4, its effect is less profound and less persistent than in fresh muscle; this shows that the fatigued synapse is more resistant to curare than the fresh one. Hoefer and Putnam [261] discuss action potentials of muscles in spastic conditions, athetosis, Sydenham's chorea, rigidity and tremor. The authors present characteristic recordings of these various conditions and say these may be definitely identified as the particular type of reaction to be expected. Putnam [262] reports recent advances in diagnosis and treatment of alternating tremor (paralysis

258. Stieda, H.: Question of Value of Bulgarian Cure with Homburg 680 (Belladonna Preparation) in Little's Disease, Med. Klin. **36**:191-192 (Feb. 16) 1940.

259. Carey, E. J.: Wave Mechanics of Smooth Muscle Action: Experimental Multiple Reflections Between Intestinal Ligatures Transform Traveling into Stationary Micropressure Waves in Smooth Muscle, Arch. Path. **29**:321-344 (March) 1940.

260. Rosenblueth, A., and Cannon, W. B.: Some Features of Early Stages of Neuromuscular Transmission, Am. J. Physiol. **130**:219-229 (July) 1940.

261. Hoefer, P. F. A. and Putnam, T. J.: Action Potentials of Muscles in "Spastic" Conditions, Arch. Neurol. & Psychiat. **43**:1-22 (Jan.) 1940; Action Potentials of Muscles in Athetosis and Sydenham's Chorea, ibid. **44**:517-531 (Sept.) 1940; Action Potentials of Muscles in Rigidity and Tremor, ibid. **43**:704-725 (April) 1940.

262. Putnam, T. J.: Alternating Tremor (Paralysis Agitans) and Athetosis: Recent Advances in Diagnosis and Treatment, New England J. Med. **222**:473-476 (March 21) 1940.

agitans) and athetosis. He states that the standard treatment of paralysis agitans of all types is the administration of drugs of the scopolamine series and that these drugs should always be tried, though the results are often disappointing. He says that administration of scopolamine should be pushed rather rapidly until the patient has toxic symptoms. The Bulgarian belladonna treatment is of questionable advantage over the older forms of therapy but may be tried if the others fail. The effect of drugs of the atropine series is sometimes increased by the auxiliary administration of amphetamine sulfate. This is particularly effective against the tics, such as oculogyric crises, that often complicate the postencephalitic type of the syndrome. He feels that curare at present is too cumbersome and dangerous for routine use.

With regard to treatment by surgical intervention, success has been reported with operations of two general types, resection of the motor or premotor cortex and section of the pyramidal tracts. The more extensive cortical operations usually produce monoplegia. For athetosis he states that the method of treatment most commonly used is reeducation of the affected muscles. This method has been reported to yield excellent results, although from the published accounts it is difficult to be sure what part of the improvement was in the associated hemiplegic disturbances. Treatment of this condition by drugs has been uniformly unsuccessful in the past. The use of curare may be beneficial, but many difficulties and dangers are to be overcome before it can be given wide acceptance. In the operative treatment of athetosis, resection of the corresponding motor cortex has brought about relief of the abnormal movements, but cortical monoplegia has resulted. Section of extrapyramidal tracts in the anterior column of the spinal cord is described, and the results of treatment are reported as favorable.

IX. FRESH FRACTURES AND DISLOCATIONS

Fracture of the Clavicle in Children.—McLaughlin [263] reports his experiences with 700 cases of fracture of the clavicle in children treated at the Presbyterian Hospital in New York during the past few years. When complete fracture of the clavicle occurs, the shoulder falls downward, inward and forward. The medial fragment remains in approximately the normal position; the outer fragment is carried away with the shoulder by its attachment to the scapula. Pain on motion and tenderness are present. The diagnosis may not be obvious with greenstick fractures; in fact, careful examination of the clavicle is always indicated with an injury of the shoulder. Regardless of deformity, the functional

263. McLaughlin, H. L.: Management of Fractured Clavicle in Children, S. Clin. North America **20**:549-556 (April) 1940.

results are uniformly good. However, in spite of the tendency of a growing child spontaneously to eliminate gross deformity, this may not disappear if the fracture is left unreduced. The cosmetic result is naturally of greater importance to girls than to boys.

The anesthesia of choice, when anesthesia is necessary, is local infiltration. In reducing a fractured clavicle, the operator places his knee between the scapulas and pulls each shoulder upward, backward and outward. The pull must be gentle, steady and slow. When the length of the clavicle is restored, the grasp on the normal shoulder is relieved, and the free hand is used for direct manipulation of the fragments. The reduction is manually maintained while an assistant applies the splint, which consists either of a well molded plastic material well padded in the axillas or of a clavicular cross. Occasionally, when there are oblique or comminuted fractures, traction is required. The arm is abducted in line with the axis of the clavicle, and skin traction is applied. Splints are usually removed after three weeks and a sling used for support. Complications are rare and consist of compression of the supraclavicular nerve, nonunion (when interposition of tissue occurs) and compression of the subclavian vessels or axillary nerve trunks. [ED. NOTE: This review is excellent. There are many methods of treating fractures of the clavicle. The important elements of treatment are fixation and frequent observation. Open reduction is seldom necessary. The effective method of the plaster yoke originally described by Billington has not been sufficiently emphasized. In 1928 one of us (H. E. C.[264]) described an original adhesive dressing, which has been successfully used for many years on ambulatory patients.]

Operative Fixation of Fractures of the Clavicle.—Murray[265] states that with the present methods of fixation for fractures of the clavicle practically all fractures unite, even though the fragments are not in good anatomic position, and that the functional results are good. The cosmetic and anatomic results are frequently disappointing.

To obviate unsatisfactory results he has developed the following method of fixation: When sufficient reduction has been obtained, a ¼ inch (0.6 cm.) incision is made 1 inch (2.5 cm.) from the inner end of the clavicle. Through this a hole ¼ inch (0.6 cm.) in diameter is drilled in the cortex. The position of the drill is gradually changed from the perpendicular until it points toward the central cylinder. Through this hole a medium-sized Kirschner wire is passed. If started in the right direction, it always travels the central cylinder and passes across the line of fracture into the distal fragment, provided the reduction

264. Conwell, H. E.: Fractures of the Clavicle, J. A. M. A. **90**:838-839 (March 17) 1928.

265. Murray, G.: Method of Fixation of Fracture of Clavicle, J. Bone & Joint Surg. **22**:616-620 (July) 1940.

is sufficient. The clavicle immediately becomes stable, and the arm, shoulder and clavicle can be moved about freely without displacement of the fragments. The wire is cut short and a small dressing placed over the incision. Later, if necessary for any reason, it can be removed with the area under local anesthesia. No other fixation except a sling is required, and the patient is comfortable. In several cases in which reduction could not be satisfactorily obtained by other means, open reduction was done. During the past three years this method has been used in 29 cases. In each case the fragments have united in good position. There have been no complications or infections in any of these cases. [ED. NOTE: Open reduction is seldom indicated for fracture of the clavicle, and the method described by Murray is to be considered carefully before it is accepted as a routine procedure. One of us (H. E. C.) has seen 2 patients who became infected after this treatment was used.]

Fractures of the Shaft of the Humerus.—Caldwell [266] shows that in his hands the use of the hanging cast or of the traction cast for the treatment of fractures of the shaft of the humerus has given a high proportion of good results with least annoyance and discomfort to the patient. The cast consists of plaster applied over stockinet only, reaching from the axilla to the base of the thumb; the elbow is flexed to 90 degrees, and the forearm is in midpronation. A bandage placed around the patient's neck is run through a wire loop incorporated in the cast at the level of the wrist. A series of 108 fractures of the shaft of the humerus is analyzed. Fractures of the surgical neck and supracondylar fractures were not included. In the 108 cases, 25 fractures were located in the upper third of the shaft of the humerus, 62 in the middle third and 21 in the lower third. Fifty-nine patients were treated by the hanging cast method; 22 of these had treatment for varying periods by balanced traction in bed. The results obtained were as follows: good union and function in 85 cases; poor position and good function in 6; poor function in 3; nonunion in 1; delayed union in 4; result not ascertainable in 9. While the hanging cast method was used more often than all other methods combined, the others used were similar in principle, except in 3 cases in which the airplane splint was used. [ED. NOTE: Caldwell was one of the first advocates of the hanging cast, and this is the report of his experiences. It must be observed that he does not use the cast routinely on every type of fracture of the humerus. He states that a knowledge of the application of the hanging cast is required and that it is by no means a panacean treatment.]

Gurd [267] presents his method of treatment for fractures of the upper two thirds of the humerus. Briefly, the treatment consists of placing a

266. Caldwell, J. A.: Treatment of Fracture of Shaft of Humerus by Hanging Cast, Surg., Gynec. & Obst. **70**:421-425 (Feb., no. 2 A) 1940.

267. Gurd, F. B.: Simple Effective Method of Treatment of Fractures of Upper Two-Thirds of Humerus, Am. J. Surg. **47**:443-453 (Feb.) 1940.

triangular pad under the axilla with a base which affords abduction of the arm of 15 degrees. The arm, shoulder and thorax are then incorporated in a plaster cast; the forearm is left free and is supported by a sling. The sling is removed in seven to ten days, and active motion of the elbow joint is begun. The cast is removed in two to five weeks; a cravat sling is supplied, and active use of the limb is advised. The method described has been used by the author for twenty years with satisfactory results, although no statistical study of end results has been made. It was not used for fractures of the anatomic neck or of the greater tuberosity of the humerus. [ED. NOTE: This is a much more logical and physiologic treatment for such fractures than the application of a hanging cast. However, both technics are more radical than the use of a plaster spica of the shoulder. When the treatment is used efficiently, however, as good, if not better, results are obtained by the use of the hanging cast or of Gurd's method than by the use of a spica of the shoulder.]

Injuries of the Elbow.—Boyer [268] stresses the importance of an accurate diagnosis of any injury of the elbow. Careful physical and roentgen examinations should be made, including determination of the presence or absence of injury to the nerves and of the state of the circulation. In dislocation of the elbow, an accompanying fracture is to be looked for. The dislocation should be reduced without delay. In a posterior dislocation the elbow should be hyperextended, and while a gentle pull is applied to the wrist, the physician should exert forward pressure on the olecranon process. The elbow is immobilized. Later, when mobilization is started, it should be gradual.

With supracondylar fractures, Volkmann's ischemia may occur. If after accurate reduction the circulation is not improved, fasciotomy should be performed. In some cases, when reduction cannot be accomplished by manipulation, traction by insertion of a Kirschner wire into the olecranon process is carried out. Reduction is accomplished by extending the arm with traction and pushing the lower fragment of the humerus forward. The forearm is then flexed and immobilized for three weeks; after this it is put in a sling for three more weeks. If an excess of callus is formed, it should be removed by operation. Whether the head and neck of the radius are removed depends on the severity of the injury. For fractures of the olecranon process with separation, internal fixation is required. With a fracture of the upper part of the shaft of the ulna, one must look for an accompanying dislocation of the radius. [ED. NOTE: The importance and efficiency of traction in severe supracondylar fractures cannot be overemphasized. The repair of the

268. Boyer, B. E.: Fractures and Dislocations of Elbow, J. Med. **20**:481-482 (Jan.) 1940.

bone and the soft tissues is usually good, and the functional result in most instances is better than after any other treatment.]

Mroz [269] stresses the importance of a neurologic examination of the arm before manipulating fractures about the elbow. Fractures about the elbow are usually accompanied by considerable swelling, depending on the amount of injury to the soft tissues. At times, if swelling is due to internal hemorrhage, it may be necessary to aspirate the mass, especially if this swelling impedes the circulation. This not only controls swelling but makes earlier reduction both safer and easier. For the purpose of discussion the following classification of fractures about the elbow joint is used by Mroz: (1) fractures of the distal end of the humerus, including supracondylar fractures, fractures of the internal condyle, fractures of the external condyle and T fractures; (2) fractures of the radius; (3) fractures of the olecranon process.

The supracondylar fracture is the commonest injury of the elbow and is usually seen in children. Under anesthesia, the arm is hyperextended, increasing the deformity, while at the same time the fragments are manipulated into position. The forearm is then flexed to about 70 or 75 degrees and immobilized with adhesive tape. Roentgenograms are taken both before and after reduction. Physical therapy is instituted as soon as union permits.

In badly comminuted and compound fractures of the elbow, skeletal traction is the treatment of choice. Traction is instituted by inserting a Kirschner wire through the proximal end of the ulna. When sufficient callus is present, a cast is applied.

Fracture of the inner or outer condyle of the humerus is another common injury. If displacement is not great, immobilization is all that is necessary. If displacement is great or impossible to maintain, the application of a beef-bone screw or metal nail is necessary.

For fractures of the head of the radius without much displacement or comminution, Mroz recommends conservative treatment. However, if there are extensive comminutions and displacement, the head of the radius should be removed. For fractures of the olecranon process without separation, manipulation is attempted, and if this is not satisfactory, internal fixation is carried out. To prevent Volkmann's ischemia the author recommends that no encircling bandages be applied and that the patient be closely observed. [ED. NOTE: The importance of early open operation for definitely separated fractures of the olecranon process cannot be overemphasized. Early motion is important, and internal fixation makes this possible.]

269. Mroz, R. J.: Fractures About Elbow Joint, Illinois M. J. **77**:218-224 (March) 1940.

Brewster and Karp [270] confirm the prevailing opinion that the functional end results in the treatment of supracondylar fractures of the humerus in children are uniformly good, even when the fractures are not accurately reduced. A diminution in the carrying angle of the elbow producing cubitus varus is often a sequel to a supracondylar fracture (28 per cent in this series) and may be caused by stimulation of the external epicondylar and capitellar epiphysis due to the fracture. This does not affect the function of the elbow. Fracture of the external condyle in a child is a serious injury and if treated in the conventional manner will result in nonunion and distortion of the elbow in a large percentage of cases. In the presence of even a minor displacement which cannot be completely corrected, open reduction is advised. Separation of the epiphysis of the medial condyle has been considered a minor injury, but if nonunion is to be avoided, open suture is advised. [ED. NOTE: This is a good article and one worthy of careful study.]

Van Gorder [271] points out that supracondylar T fracture of the humerus can be reduced in most cases by other means than open operation. The importance of preoperative planning and preparation is stressed, and the kinds and shapes of materials desired for internal fixation are described. By fitting his plates on a skeleton to estimate the lengths of screws, bolts or other materials, he saves much valuable time. During operation on a fracture of this type the patient lies face down while his arm with a small pneumatic tourniquet applied is flexed over an arm board. A posterior midline cutaneous incision is made from 5 inches (12.5 cm.) above the olecranon process to 1 inch (2.5 cm.) below its tip. Skin and subcutaneous tissue are widely separated. The ulnar nerve is gently retracted. The superficial fascia over the triceps muscle is cut in the shape of a tongue, the apex of which is about 4 inches (10 cm.) above the olecranon process. This gives an admirable and safe exposure of the fracture, facilitating reduction and allowing the free use of plates, screws, bolts or wire for fixation. The author illustrates his article with sketches which show many excellent reductions maintained by the ingenious use of internal fixation. [ED. NOTE: This is an excellent technic and aids greatly in operations on this difficult fracture.]

Jackson [272] reports an interesting case of anterior dislocation of the elbow with rupture of the brachial artery. Such a combination of

---

270. Brewster, A. H., and Karp, M.: Fractures in Region of Elbow in Children: End-Result Study, Surg., Gynec. & Obst. **71**:643-649 (Nov.) 1940.

271. Van Gorder, G. W.: Surgical Approach in Supracondylar "T" Fractures of Humerus Requiring Open Reduction, J. Bone & Joint Surg. **22**:278-292 (April) 1940.

272. Jackson, J. A.: Simple Anterior Dislocation of Elbow Joint with Rupture of Brachial Artery; Case Report, Am. J. Surg. **47**:479-486 (Feb.) 1940.

injuries is extremely rare according to the literature. The patient had good results after reduction of the dislocation and suture of the brachial artery. [ED. NOTE: This is indeed a rare dislocation, and Jackson is to be congratulated on the excellent results obtained.]

Griesemer [273] presents a study of external dislocation of the elbow which indicates that reported cases both of complete and of incomplete external lateral dislocation are infrequent. This type of dislocation is often accompanied by fracture in or about the elbow joint or at a lower level of the forearm. Good results are to be expected if reduction is done early. A ten day old dislocation requires open reduction. If early closed reduction fails, open operation should be performed at once. Extensive lacerations of the skin and swelling of the joint as a rule contraindicate operation, unless the patient is seen within three hours after the accident. Fixation should be maintained in supination with flexion at the elbow to as acute an angle as the swelling permits. It is wise to hospitalize the patient several days for observation. Early active motion is essential in either open or closed reduction to obtain early restoration of joint function. Griesemer reports 6 cases. [ED. NOTE: This is an unusually large series. In these cases, if proper handling is not instituted early, the results are usually poor. Injuries of the nerves, especially of the radial and ulnar nerves, are frequent complications. One of us (H. E. C.) observed an injury of the radial nerve which cleared up without surgical intervention.]

Speed and Boyd [274] ably present a study of a series of 62 injuries of the elbow with fracture of the ulna associated with dislocation of the head of the radius (Monteggia fracture). Thirty patients had acute fractures; 10 had compound fractures, and the remaining 32 had old injuries of four weeks' or longer duration. In the treatment of these patients it was found that the closed method is usually unsatisfactory for adults. The treatment of choice was open reduction with internal fixation of the fragments of the ulna with a vitallium plate and replacement of the radial head, made secure by a fascial loop around the neck of the radius. Closed reduction may be used for acute fractures in children. However, accurate replacement of the radial head is difficult and the fracture is apt to recur.

For nonunion of the ulna and dislocation of the radial head, resection of the head and of the neck of the radius combined with an onlay bone graft of the ulna fastened by vitallium screws is recommended. Disturbances of the lower radioulnar articulation have not been of sufficient

273. Griesemer, W. D.: External Lateral Dislocation of Elbow, Am. J. Surg. **47**:57-70 (Jan.) 1940.

274. Speed, J. S., and Boyd, H. B.: Treatment of Fractures of Ulna with Dislocation of Head of Radius (Monteggia Fracture), J. A. M. A. **115**:1699-1705 (Nov. 16) 1940.

practical importance to contraindicate resection of the head and the neck of the radius. Injury of the radial nerve is avoided by the anatomic approach described.

Fractures of Both Bones of the Forearm.—Key [275] presents 8 cases of fracture of both bones of the forearm in which the fragments were displaced. The ages of the patients ranged from 8 to 60 years. Key concludes that if a satisfactory and stable reduction cannot be obtained at the first attempt open reduction and internal and external fixation should be resorted to if adequate facilities are at hand. For internal fixation he prefers inserting small stainless steel wire loops and sprinkling sterile sulfanilamide powder in the wound. For external fixation long posterior and short anterior wood splints encased in a plaster of paris cast give the best results. The cast extends from the middle of the upper part of the arm to the base of the fingers, with the palm left free for exercise of the thumb and the fingers.

Injuries of the Wrist.—Hyman and Martin [276] state that fracture of the radius is not uncommonly complicated by dislocation of the inferior radioulnar joint. They give a classification of such lesions, and discuss the causes, mechanics and pathologic anatomy. They present 25 cases. Immediate treatment consists of reduction after manipulation with the patient under anesthesia induced by gas and oxygen and immobilization in a plaster cast to maintain reduction. When the dislocation of the head of the ulna was anterior, the wrist was fixed in palmar flexion; when the dislocation was posterior, the wrist was fixed in dorsiflexion. In no case was open reduction necessary. Active use of the fingers, shoulder and elbow is to be insisted on after reduction. The cast was retained for four to eight weeks, except in 1 case, in which the shaft of the radius was broken. Removal of the cast was followed by active movements. The prognosis is good for posterior dislocation of the head of the ulna associated with fracture of the shaft of the radius or of the lower 1 inch (2.5 cm.) of the radius and for anterior dislocation of the head of the ulna with fracture of the radial shaft. However, the prognosis is not good for anterior dislocation of the head of the ulna associated with a bad Colles fracture. [ED. NOTE: This is an excellent and timely paper. Too little attention is given to injuries of this kind in the acute stage. They frequently go undiagnosed and cause irreparable damage.]

---

275. Key, J. A.: Common Problems in Surgical Diagnosis: Treatment of Complete Fractures of Both Bones of Forearm, S. Clin. North America **20**:1393-1412 (Oct.) 1940.

276. Hyman, G., and Martin, F. R. R.: Dislocation of Inferior Radio-Ulnar Joint as Complication of Fracture of Radius, Brit. J. Surg. **27**:481-491 (Jan.) 1940.

Fisher and Segal [277] conclude that:

1. Injuries of the carpal bones are frequently missed due to failure of the patient to seek medical attention or to lack of adequate roentgenologic study.

2. The navicular is the most frequently fractured and the lunate the most frequently dislocated bone of the wrist. Radiocarpal dislocation is rare, whereas peri-lunar dorsal dislocation is the most common dislocation of the carpus.

3. Nonunion and secondary changes are due to interference with the blood supply and failure to immobilize early and for an adequate length of time.

4. Prognosis is dependent on early recognition, prompt reduction, and prolonged immobilization.

5. Fresh navicular fractures should be immobilized in the position of dorsiflexion and radial deviation for an eight to twelve week period.

6. Old or neglected cases with nonunion, osteolytic, or arthritic changes should be treated by total excision of the entire navicular followed by early mobilization and physiotherapy.

[ED. NOTE: The authors do not emphasize sufficiently either the treatment for the dislocated lunate bone or the rarity of necrosis.]

Thorndike and Garrey [278] state that among the commonly undiagnosed fractures are those of the carpal scaphoid bone (os naviculare). They have seen 17 patients in a college clinic. Eleven of these had old or previously unrecognized fractures. The incidence is high in young men active in sports in which violent hyperextension of the hand takes place. The standard signs for diagnosis are limitation of motion in extension and radial deviation with tenderness over the anatomic snuff box and on the palmar surface over the tubercle of the bone. One obviously incorrect diagnosis frequently made is that of a sprained wrist. The failure to demonstrate these fractures by roentgenograms, especially in the initial roentgen examination, is frequently mentioned. Better views may be taken with the fist clenched and the fingers resting on the x-ray plate with the palm down in extreme ulnar deviation and extreme pronation. If a true undetected fracture is present and motion is permitted, absorption of the bone occurs along the fracture line, and the fracture becomes more evident in one to two weeks. Rigid rest will halt absorption and allow gradual union to take place. These authors use the anatomic classification of fracture of the carpal scaphoid. Fractures through the tuberosity are extra-articular and always heal in four to six weeks by bony union. Fractures through the middle and proximal third of the body of the scaphoid bone constitute the majority of injuries. Fresh fractures show little or no displacement. Treatment is standard-

277. Fisher, D., and Segal, J.: Injuries of Wrist, Mil. Surgeon **86**:134-142 (Feb.) 1940.

278. Thorndike, A., Jr., and Garrey, W. E.: Fractures of Carpal Scaphoid, New England J. Med. **222**:827-830 (May 16) 1940.

ized, and early diagnosis and effective immobilization are the key to good results. Conversely the motion of five articulating surfaces in frequent movements of the hand is the one certain common cause of absorption. The fragments are best apposed with the wrist in 40 to 50 degrees of extension. Rigid immobilization should be carried out for twelve weeks with an additional four weeks of partial immobilization in a supportive gauntlet. Results of later operative treatment in cases of nonunion have been good. [ED. NOTE: One of us (H. E. C.) has found that abduction of the hand at the wrist (the Soto-Hall technic) is important in addition to the extension mentioned by these authors. This type of fracture too often goes unrecognized.]

Fractures of the Hand.—McNealy and Lichtenstein [279] present a summary of the deformities of the metacarpal bones and the phalanges following fractures of the hand. Although a thorough understanding of the attachment of tendons and the direction and force of their pull is preferable in immobilization of the affected bone, they set forth the general principle of alining the mobile distal fragment with a less mobile proximal fragment. This rule simplifies the essentials of treatment and relieves one of remembering the mechanisms involved in various displacements. It is applicable to all fractures of the bones of the hand. [ED. NOTE: Too little attention is given to the early treatment and rigid convalescent care of patients with fractures of the metacarpal bones and the phalanges. This lack of interest is causing too frequent disabilities, which is turn cause considerable economic loss. Such disabilities and economic loss could be prevented by early and proper attention to these simple fractures.]

Fractures of the Acetabulum.—Maynard [280] presents an important study of fracture of the acetabulum. The cause is a fall or a blow striking on the greater trochanter and hip region. There are slight flexion, abduction and external rotation of the thigh with not more than ½ inch (1.27 cm.) shortening. There is limitation of motion of the hip. Crepitation may be present. The greater trochanter is posterior and less prominent. The patient is put on a fracture bed or hard bed and treated for shock; 10 to 20 pounds (4.5 to 9.1 Kg.) of longitudinal and lateral traction is applied to the extremity. After a few days, when the patient has recovered from shock, manipulation with the aid of general anesthesia should be done. The hip is manipulated in all directions to break up impaction, if any is present. The thigh is then flexed on the abdomen and the leg on the thigh, each to a right angle or more. Forcible adduc-

279. McNealy, R. W., and Lichtenstein, M. E.: Fractures of Bones of Hand, Am. J. Surg. **50**:563-570 (Dec.) 1940.

280. Maynard, R. L.: Reduction of Fractures of Acetabulum with Penetration of Head of Femur into Pelvis: Report of Three Cases, Rhode Island M. J. **23**:150-153 (Sept.) 1940.

tion and internal rotation of the extremity are done against a lateral pull placed as high on the inner aspect of the thigh as possible. The patient is returned to bed, and longitudinal and horizontal traction are continued for four to six weeks. After this he remains in bed two to four weeks longer. Then he uses crutches for about two months. In all of Maynard's cases there was some recurrence of deformity with limitation of adduction, internal rotation and flexion of the hip. There was no shortening of consequence, and only a slight limp was apparent. Functional results were good. [ED. NOTE: Latent changes in the bones about the head of the femur and the acetabulum following trauma should always be looked for, especially with injuries as severe as those described.]

Dislocation of the Hip.—De Yoe [281] describes a modification in the method of Allis for reducing posterior dislocations of the hip. The patient is anesthetized while lying on his back and is so placed that the buttocks are at the end of the table. An assistant holds the normal leg horizontally, or it may be placed on a small table of the same height as the operating table. The pelvis is now strapped to the table or firmly held there by an assistant. The operator takes the dislocated leg, flexes the thigh; with his back against the end of the table and against the patient's buttocks he then brings the dislocated leg over his shoulder. The operator's shoulder is now under the popliteal space. The knee is flexed, and the back of the patient's calf lies against the operator's chest. With the leg firmly held in this position, the operator lifts upward and bends forward easily, exerting powerful traction on the femur. The dislocating force is thus reversed. With an audible click the head of the femur snaps into the acetabulum, and the motion of the thigh is no longer restricted. It is important to make roentgenograms of the hip before manipulation to determine the presence or absence of associated fractures of the pelvis or femur. [ED. NOTE: This is a unique modification of Allis' technic. The taking of roentgenograms before attempt at reduction is indeed a necessary procedure, especially so far as medicolegal aspects are concerned.]

Walker [282] points out that traumatic dislocations of the hip constitute 2 to 5 per cent of all dislocations. The most common cause is a severe blow on the flexed knee. The dislocations are classified as anterior or posterior according to their relation to Nélaton's line, which bisects the acetabulum, and further as high or low, depending on the final resting place of the dislocated head. Posterior dislocations are seven times more common. Associated with dislocation of the hip are considerable shock,

281. De Yoe, L. E.: Suggested Improvement to Allis' Method of Reduction of Posterior Dislocation of Hip, Ann. Surg. **112**:127-129 (July) 1940.

282. Walker, W. A.: Traumatic Dislocations of Hip Joint, Am. J. Surg. **50**: 545-549 (Dec.) 1940.

trauma of the soft parts and frequently fracture of the acetabular rim. The ligamentum teres femoris and the capsule are always torn. The characteristic position in posterior dislocation is flexion, adduction and internal rotation. The position is relatively fixed. The greater trochanter is above Nélaton's line. In anterior dislocation the leg is in external rotation and abduction. There may be slight flexion and extension. Because of the powerful musculature, general anesthesia is necessary for relaxation. During any manipulative procedure, the sole object is to return the head to its socket along the path it traveled while dislocating. To do this with a minimum of trauma, the head must be disengaged from the soft parts and returned to the acetabulum through the original tear in the capsule. In all methods of reduction, flexion of the thigh to about 90 degrees to relax the Y ligament and bring the head opposite the tear in the capsule is essential. Aseptic necrosis of the femoral head after dislocation has been noted. This is due to loss of blood supply, which is maintained through the ligamentum teres, the capsule and the neck. Thus it is important to be careful in manipulating and immobilizing the extremity. The extremity should be protected from early weight bearing. Other sequelae are myositis ossificans of the capsule and injury of nerves. [ED. NOTE: Necrotic changes of the head of the femur following dislocation and fracture are now more frequently recognized than ever before. As the author states, too early weight bearing by the extremity should never be allowed.]

Fractures of the Neck of the Femur.—Moore and Green [283] report 50 consecutive cases of intracapsular fracture of the neck of the femur which have been followed for one to five years. In this group solid bony union developed in 45 cases, or 90 per cent, and questionable union in 1, or 2 per cent; there was definite nonunion in 4, or 8 per cent. The authors stress the fact that, although the procedure of nailing the hip is not difficult, it is a formidable procedure for the occasional operator to undertake. Early in the series three nails were used, but in the later cases two nails were applied in the upper portion of the neck and two nails in the lower portion. This has an increased stabilizing value. The patient may be up on crutches without weight bearing in a few days, but actual weight bearing is not allowed for six months. [ED. NOTE: Internal fixation of intracapsular fractures has its place and advantages. The Whitman abduction cast is being used less as time goes on. The authors are to be congratulated on their higher percentage of unions. Their percentage, however, is much higher than that reported in the final analysis of the Fracture and Traumatic

283. Moore, A. T., and Green, J. T.: Fractures of Neck of Femur Treated by Internal Fixation with Adjustable Nails: End Result Studies, South. Surgeon 9:684-689 (Sept.) 1940.

Committee of the American Academy of Orthopaedic Surgeons [284] for this or other methods of internal fixation.]

Speed [285] states that in fractures of the neck of the femur in the aged a change in the axis leads to changed mechanics of support, often followed by early absorptive changes in the bone. The rule of treatment must be (1) reduction with the patient under proper anesthesia, (2) fixation by operation and (3) appropriate after care.

Proper preoperative treatment is essential. Shock should be treated and a fluid balance established. A gentle and yet thorough physical examination should be made. Before operation temporary fixation by means of traction is advised. Any pathologic condition should be treated. For the anesthetic Speed prefers nitrogen monoxide and oxygen or ethylene; for a second choice he favors local infiltration of procaine hydrochloride.

Fixation may be secured by a Smith-Petersen nail, finer pins or a combination of nail and bone transplant. The last is the method of choice for fractures which have existed for three months without union.

The author states that the percentage of early deaths after operation is not more than 1 when the treatment has been efficient. The complications listed are infection in the nail or pin tracts and loosening of the nail or pins. Death of the head may occur, but more frequently replacement of bone by revascularization occurs. Protection from weight bearing for six months or more is important. After operation the activity of the patient should be restored as quickly as possible, and he should be put in a chair in about one week. No weight bearing by the injured leg should be permitted until the trabeculae of the bone are firmly reestablished and this is demonstrated in roentgenograms.

Gissane, Blair and Rank [286] present 4 cases of fracture of the neck of the femur which resulted from convulsive therapy administered to patients with mental disorders. The average age was 41. However, attention is called to the fact that extracapsular fractures and intracapsular fractures of the neck of the femur most commonly occur in the aged and feeble. The 4 patients whose cases are presented had all been consigned to institutions for prolonged treatment before convulsive therapy was administered. The authors conclude that the bones have become atrophic from disuse and consequently are liable to fracture if undue strain is placed on them.

---

284. Treatment of Fractures of the Neck of the Femur by Internal Fixation, Report of the Fracture Committee of the American Academy of Orthopaedic Surgeons, J. Bone & Joint Surg. **23**:386-390 (April) 1941.

285. Speed, K.: Symposium on Surgery of Aged: Management of Fractures of Neck of Femur by Operative Fixation, S. Clin. North America **20**:75-96 (Feb.) 1940.

286. Gissane, W.; Blair, D., and Rank, B. K.: Fractures of Neck of Femur in Convulsion Therapy, Lancet **1**:450-453 (March 9) 1940.

The conclusions drawn from the authors' experiences and a review of the literature are:

1. Convulsive therapy should not be used for elderly persons or for those who have had a prolonged period of inactivity.

2. The minimal number of injections should be used.

3. After the treatment, a routine examination of the skeletal system is indicated.

4. Once the fracture has been diagnosed, the usual treatment should be given.

5. After adequate nailing, there is no reason to withhold further convulsive therapy, if this is still indicated. [ED. NOTE: One of us (H. E. C.) agrees with the authors. However, in 1 of his cases in which there was bilateral fracture of the neck of the femurs following such therapy, the patient was 40 years old and had good bone structure, which was in no way atrophic.]

Harris [287] presents 2 cases, in each of which a Smith-Petersen nail was so firmly fixed in the cortex of the femoral shaft that as the neck shortened the nail penetrated the acetabulum. The nail had not been extruded as usually happens with shortening of the femoral neck. In 1 case the fixation was difficult to explain, but in the other case it was due to callus over the head of the nail. In both cases the symptom of painful motion of the hip resulted from the perforation of the femoral head. This complication in the use of the three-flanged nail contraindicates the use of such fixation of the head of the nail to the femoral shaft, advocated by several surgeons. [ED. NOTE: The conclusions by Harris do not bear out the observations of the Fracture and Traumatic Committee of the American Academy of Orthopaedic Surgeons [284] on the treatment of fractures of the neck of the femur by internal fixation. This committee found that not only the Smith-Petersen nail but also the Moore nail and other types of fixative material intruded into the acetabulum in 5 per cent of 572 cases; there was extrusion in 8 per cent.]

Christopher [288] presents 5 cases of impacted fracture of the neck of the femur in which treatment by means of a short abduction spica, elevation of the heel of the shoe on the normal side and early walking resulted in union and complete recovery. This treatment was a modification of the method of Apfelbach and Aries,[289] who reported 22 cases

287. Harris, H. W.: Intrusion of Smith-Peterson Nail into Acetabulum, J. Bone & Joint Surg. **22**:999-1003 (Oct.) 1940.

288. Christopher, F.: Treatment of Impacted Fracture of Neck of Femur, J. Bone & Joint Surg. **22**:161-167 (Jan.) 1940.

289. Apfelbach, G. L., and Aries, L. J.: Ambulatory Treatment of Fractures of the Neck of the Femur, Surg., Gynec. & Obst. **63**:341-348 (Sept.) 1936.

of complete fracture of the neck of the femur with good results in 17. The so-called impacted fracture practically always calls for the same treatment as other fractures of the neck of the femur. [ED. NOTE: It has been the experience of one of us (H. E. C.) that if the general condition of the patient permits impacted fractures of the neck of the femur should be treated as any displaced fracture of the neck of the femur, that is by nailing. How can one always tell how complete and stable the impaction of fractures is?]

Wilson [290] reports a series of 10 cases of fracture of the neck of the femur in children observed over a ten year period. A close study of this series forces him to conclude that such fractures are serious injuries and are not always followed by good functional results as most authors report; that maintenance of reduction in the Whitman cast is difficult; that while a nail would perhaps be more effective, there is a possibility that it will damage the epiphysial plate. Changes with growth are to be expected. The disturbances of growth in patients of this series do not conform to the classic picture of Legg-Calvé-Perthes disease. Oblique subtrochanteric osteotomy is helpful in bringing a limited arc of motion into useful planes. In this series there were 7 boys and 3 girls; 4 were in the first and 6 in the second decade of life. One of the children died. The case of another is too recent to report. In 2 of the remaining 8 there were good functional results. [ED. NOTE: This is an excellent and reliable report of results in treating a type of fracture which has not been considered seriously enough in the past.]

Trochanteric Fractures of the Femur.—Leydig and Brooks [291] report that there is a high mortality rate among patients with trochanteric fractures of the femur. In a series of 302 cases at the St. Louis City Hospital the rate was 39.3 per cent. A survey of seven of the larger private hospitals in St. Louis revealed a mortality of 25 per cent in 335 cases. This is in contrast to the mortality of about 14 per cent implied by the literature and textbooks. The fractures occurred at the average age of 70. If patients withstand the initial shock of injury, they apparently do not well tolerate the treatment, which to be adequate ordinarily requires prolonged immobilization in bed.

Since excellent results were obtained with Smith-Petersen nails, in cases of fracture of the neck of the femur, it was thought that this treatment could be used for fractures of the trochanters. It was used in a series of cases, but apparently the nails did not adequately immobil-

290. Wilson, J. C.: Fractures of Neck of Femur in Childhood, J. Bone & Joint Surg. **22**:531-546 (July) 1940.

291. Leydig, S. M., and Brooks, T. P.: Treatment of Pertrochanteric Fracture of Femur with Lag Bolt, J. Missouri M. A. **37**:354-357 (Aug.) 1940.

ize the fractures, as in every case there resulted coxa vara and shortening of various degrees.

The mechanics of immobilization by internal fixation in fracture through the neck of the femur and in trochanteric fractures are entirely different. There is a greater shearing action in the latter. For this reason a lag bolt similar to the lag screw of Henderson was devised, which in the opinion of the authors is simple. The patient is prepared with morphine and scopolamine, and the site of the fracture is infiltrated with procaine hydrochloride. The fracture is reduced by traction and abduction. A roentgenogram is taken, and if the reduction is satisfactory an incision is made 1¼ inches (3.2 cm.) below the greater trochanter. A 7/32 inch (0.56 cm.) drill hole is started in the correct direction, and anteroposterior and lateral roentgenograms are taken. If the position is faulty, the direction should be changed. The lag bolt is fitted into a brace and screwed into the drill hole. A wedge-shaped washer is applied, and the prongs of the washer are tamped into the cortex. The washer serves two purposes, namely, preventing rotation of the bolt and diffusing the pressure of the nut over a larger area of the cortex of the shaft. The nut is tightened over the washer, and the wound is closed. The authors have found this method of internal fixation of trochanteric fractures satisfactory. [ED. NOTE: In the past few years much interest has been manifested in the treatment of trochanteric fractures. The high mortality rate in the cases of the authors has not been experienced by many other investigators. However, certain surgeons have had a relatively high mortality rate. Theoretically, internal fixation is ideal for such fractures; however, in using internal fixation surgical shock is to be seriously considered. The authors' technic seems to give less shock and be more ideal than similar methods.]

Fractures of the Shaft of the Femur.—Le Mesurier [292] treats fracture of the femoral shaft in children over the age of 2 by placing the leg in a Thomas splint and having the patient lie on an inclined Bradford frame. The tilt of the frame regulates the amount of extension obtained. The end of the Thomas splint is tied on the top of the end rail of the bed so that it cannot rotate. The inclination of the frame should be about one in three; if the frame is 6 feet (182 cm.) long, the inclination should be 2 feet (60 cm.) higher than the head. After about four weeks, when roentgen examination shows callus, a cast is applied. For patients under the age of 2, Le Mesurier uses vertical suspension. He points out that union generally occurs rapidly in children's fractures. [ED. NOTE: One of us (H. E. C.) has had good results in treating fractures of the femur in children up to the age of

292. Le Mesurier, A. B.: Treatment of Fractures of Shaft of Femur in Children, Am. J. Surg. **49**:140-146 (July) 1940.

5 or 6 years with over head extension. The author's technic for older children is good. However, there is not much difference between his treatment and the well known and long-practiced extension position used in treating fracture of the femur in adults, except that the author does not use skeletal traction. Skeletal traction is seldom desirable or indicated for treating fractures in children.]

Van Gorder [293] reports 58 cases of fracture of the shaft of the femur. The patients were adults and were treated by skeletal traction. After a careful analysis the following facts are presented: The average stay of the patient in the hospital was eleven and a half weeks. There were 3 cases in which there was nonunion. Of a total of 41 cases 13, or 31 per cent, in which the length of the leg was measured showed an average shortening of ⅞ inch (2.2 cm.). Motion of the knee joint was limited in 11 of 43 cases, or 25 per cent, with an average limitation of the total range of 76.5 degrees. The average time that elapsed between the date of injury and the date when the patient resumed work was seven and one fourth months. The end results of treating the 58 patients were excellent in 57 per cent, good in 30 per cent and poor in 8 per cent. [ED. NOTE: When properly used the open method of treating fractures of the shaft of the femur necessitates a shorter period of hospitalization, but this report shows that treatment by the closed traction method also gives good results. It takes capable surgeons to use either method, and good supervision and training are demanded by either procedure. No one method is applicable to every case; a decision regarding each case should be made separately.]

In a discussion of fracture of the femur Voshell and Verda [294] present their experiences with the Anderson method of automatic ambulatory treatment. Reduction is accomplished by inserting two pins at a fixed angle to each other into the proximal fragment near the trochanter and two straight pins through the distal fragment near the knee. With the patient lying on the fluoroscopic table in a special traction apparatus which attaches to the pins, the fracture is reduced. A short strong cast is then applied from the groin and buttocks to the knee joint, incorporating both the proximal and the distal pins. The average stay of these patients in the hospital was nine and a half days. In all, 22 patients were treated. Two deaths occurred from bronchopneumonia; both the patients were old people. In 6 cases union was not yet accomplished after three months, but union was ultimately effected in all without surgical intervention.

---

293. Van Gorder, G. W.: Treatment of Fractures of Shaft of Femur by Skeletal Traction and Thomas Splint, Am. J. Surg. **49**:149-154 (July) 1940.

294. Voshell, A. F., and Verda, D. J.: Fractures of Femur Treated by Automatic Ambulatory Method of Roger Anderson, Am. J. Surg. **49**:175-176 (July) 1940.

Injuries of the Knee.—Anderson [295] reports a case of fracture of the tibial spine. A satisfactory result was obtained by fixation of the leg in extension in a plaster cast. Fracture of the tibial spine and an avulsion fracture of the tibial attachment of the anterior crucial ligament he states are distinctly separate conditions and should be differentiated. In anatomic dissections of 16 knee joints he found that the anterior crucial ligament was firmly attached to the anterior intercondyloid fossa of the tibia. [ED. NOTE: This is a good article and worthy of more careful study.]

Leadbetter and Hand [296] describe the mechanism of fracture of the tibial plateau and discuss the technic of open reduction of the fracture. This paper is based on a study of 23 cases; in 16, or 70 per cent, the fracture was treated by open reduction. Removal of a meniscus was necessary in 12 of these; some form of internal fixation was necessary in 4. In 9, or 56 per cent, a good functional result was obtained; extension was complete, and flexion was beyond a right angle. In 1 case there was moderate genu valgum with good function. In 2 cases fair functional results were obtained, but the postoperative period of convalescence is as yet too short to evaluate the results. Of 7 patients treated by closed reduction, 2 had normally functioning knees, and 3 had limited motion, instability and pain. Two others did not return for study. In the procedure advocated by the authors the damaged soft structures are removed, good contour is restored to the lateral tibial plateau at its weight-bearing surface, and spongy subchondral bone is packed and compressed underneath the plateau for support. Many disconcerting disabilities may be prevented with this procedure. [ED. NOTE: This is a serious fracture, and it demands close and careful treatment. An after-treatment precaution is prolonged freedom from weight bearing.]

Barr [297] states that in a series of cases of fracture of the upper part of the tibia, fracture of the outer condyle without associated fracture of the fibula was the type present in 40 per cent and that this is the most common type encountered. For purposes of treatment Barr classifies the cases according to the displacement of the fractured fragments: slight, moderate or marked. This type of fracture assumes a fairly constant form, in which there is a comminuted depression of the central portion of the articular surface of the lateral condyle and a lateral displacement of a large marginal fragment. Manipulation is futile; treatment consists of open reduction and fixation. [ED. NOTE: All patients

295. Anderson, E. R.: Fracture of Spine of Tibia (Intercondyloid Eminence), Minnesota Med. **23**:674-677 (Sept.) 1940.

296. Leadbetter, G. W., and Hand, F. W.: Fractures of Tibial Plateau, J. Bone & Joint Surg. **22**:559-568 (July) 1940.

297. Barr, J. S.: Treatment of Fractures of External Tibial Condyle (Bumper Fractures), J. A. M. A. **115**:1683-1687 (Nov. 16) 1940.

with fractures of this type do not demand treatment by open reduction. One of us (H. E. C.) has treated several patients with fracture of this type by the closed method. However, this does not mean that surgical intervention is never indicated. It is required in cases in which there is marked displacement.]

Macklin, Hartman and Peterson [298] report 2 cases of dislocation of the head of the fibula and review the literature on the subject. The diagnosis is made from the history of the onset of pain localized to the region of the head of the fibula and aggravated by motion of the knee joint. The head of the fibula is tender to palpation. There is less pain with the knee flexed. Anteroposterior and lateral roentgenograms show the displacement clearly, but the diagnosis may be missed if one has no previous knowledge of the condition. In a few cases the condition becomes chronic and the patient complains of weakness in the leg. The dislocation usually occurs after a fall on the inverted foot or on the leg doubled up under the body, but it may also be caused by a direct blow or, more rarely, by the pulling action of the muscles. Reduction is accomplished by manual pressure with the knee in flexion to relax spasm of the biceps. Fixation for four to six weeks is recommended. [ED. NOTE: Reduction and maintenance of the position with such an injury is not always as simple as the authors would lead one to believe. However, even with deformity and malposition, functional results are frequently surprisingly good. The authors have outlined an excellent procedure for the treatment of this disability. Open operations are seldom indicated, but one of us (H. E. C.) knows of 1 case in which the surgeon removed the upper end of the fibula with good functional results. Such surgical intervention is not to be carried out except for chronic painful conditions which are not amenable to other treatment.]

Fractures of the Shafts of the Tibia and Fibula.—Swart [299] presents a series of 68 cases of fractures of the shafts of the tibia and fibula treated by the Anderson splint. The number of cases of infection, nonunion and slow union is presented, with reasons for these results. The advantages of the method are: The method is positive and certain for early reduction and fixation; the fragments do not slip in the cast; the period and expense of hospitalization are minimized; the patient can walk with crutches at an early date; practically no pain is present after reduction. The disadvantages of the method are: The possibility of infection of the bones is always present; if overpull is not corrected, slow union or non-

298. Macklin, W. E.; Hartman, C. M., and Peterson, H. O.: Dislocation of Head of Fibula: Report of Two Cases, Minnesota Med. **23**:649-650 (Sept.) 1940.

299. Swart, H. A.: Analysis of Treatment of Sixty-Eight Cases of Fractures of Shafts of Tibia and Fibula with Roger Anderson Splint, South. M. J. **33**:1081-1085 (Oct.) 1940.

union may be the result; rather elaborate equipment is necessary; walking irons cannot be used.

The end results were known in 43, or 63 per cent, of the cases; 39 of these or 90 per cent, were good, and 4, or 9.3 per cent, were poor. Seven, or 10.3 per cent, are still under observation, and the results in 16, or 23.5 per cent, are not known. [ED. NOTE: This is an excellent summary, and the conclusions are reliable. No treatment is infallible or panacean. There must be no forgetting the dangers or making indiscreet use of this or similar technics.]

Nelson and Jenson [300] discuss a most important complicated fracture, namely, the "trimalleolar" fracture of the ankle. This was first described by Cooper over a century ago. The term "trimalleolar" is used as a convenience to include the posterior lip of the tibia as a "posterior malleolus." Of 359 cases of fractured ankles, over a period of five years, 77 "minimal" and 10 "classical" trimalleolar fractures were treated. Eight of the 10 cases of "classical" fracture were followed up. From their experience with these cases the authors draw the following conclusions:

1. "Minimal" trimalleolar fracture is a trimalleolar in which the posterior tibial fragment comprises less than one-third of the anteroposterior measurement of the distal articular surface of the tibia. It can in every case be adequately reduced by manipulation under anesthesia with the knee flexed to 90 degrees, and reduction maintained by a plaster cast from the toes to the knee with the foot flexed to a right angle and in mid-position as regards inversion and eversion.

2. "Classical" trimalleolar fracture is a trimalleolar in which the posterior tibial fragment comprises one-third or more of the anteroposterior measurement of the distal articular surface of the tibia. It can be reduced by manipulation, but the reduction can not be maintained in every case, even if the cast extends from the toes to the groin with the knee held in 90 degrees flexion. Therefore, it should be opened, preferably within the first few hours when the skin is still in good condition and swelling absent or minimal. We use Speed's incision—just to the medial margin of the tendo Achillis and vitallium screws to fix the posterior fragment in place. A light dressing is applied, the ankle manipulated to reduce the fractures of the medial and lateral malleoli, and the leg is placed in plaster exactly as for the minimal fractures.

3. In some cases of "classical" trimalleolar fracture, three directional traction in a plaster cast will obtain and maintain reduction; but, because this is uncertain, we believe that it is better to operate immediately. Repeated manipulations, manual or combined with skeletal traction, traumatize the skin and by so doing very frequently preclude any open surgery.

Fracture of the Os Calcis.—Dieterle [301] reports 1 case in which a man aged 50 had a so-called "open beak" fracture of the os calcis. Open

300. Nelson, M. C., and Jenson, N. K.: Treatment of Trimalleolar Fractures of Ankle, Surg., Gynec. & Obst. **71**:509-514 (Oct.) 1940.

301. Dieterle, J. O.: Case of So-Called "Open-Beak" Fracture of Os Calcis, J. Bone & Joint Surg. **22**:740 (July) 1940.

reduction was necessary because initial reduction had been delayed on account of ecchymosis and swelling. Good results were obtained.

Dieterle states:

> This fracture is quite rare and, as stated by Böhler, presents no difficulty in reduction. The tubercle of the os calcis is not pulled upward by the Achilles tendon, but is split off and held in the position as shown by impingement of the sharp edge of the fragment against the Achilles tendon. With the foot in the plantar-flexed position, reduction by manipulation should be easy, provided there are no complications such as occurred in the case reported.

[ED. NOTE: In our opinion this rare fracture is not as easy to reduce by the closed method as Böhler and Dieterle seem to think; open reduction would seem to be indicated in most cases.]

Injuries of the Spine.—Sinberg and Burman [302] state that the treatment of fractures of the atlas, whether of the lateral, the anterior or the posterior arch, is the same as the treatment of fractures elsewhere in the cervical region of the spine. The patient's neck is hyperextended in bed by traction, and a plaster jacket of the Calot type is applied when the acute stage is over. This jacket is worn until healing occurs. At this time the neck is supported by a brace and physical therapy is given. The total duration of treatment is as for any injury in the cervical region of the spine, about seven to ten months. Two cases of fracture of the posterior arch of the atlas with associated fractures of the cervical region of the spine at the other points are presented. According to the authors, this association seems to be the rule in such cases. [ED. NOTE: 'Great care should be exercised to make certain that the spinal cord is not injured before applying traction in treating injuries in the cervical portion of the spine.]

Wilson, Michele and Jacobson [303] state that spontaneous dislocation of the atlantoaxial articulation is a dislocation occurring without known trauma or discernible organic disease of the bone. The authors report 1 case of their own, in which there was complicating quadriplegia, and cite 28 other cases from the literature. They found the incidence equal in the two sexes. The majority of patients were between 5 and 12 years of age; the youngest was 2, and the oldest, 62. The authors' case with the complication of quadriplegia was the only one in which there was involvement of the spinal cord. They observed that dislocation is preceded by infection, most often in the nose and the throat, and that head traction is the best method of reduction and should be followed by use

302. Sinberg, S. E., and Burman, M. S.: Fracture of Posterior Arch of Atlas, J. A. M. A. **114**:1996-1998 (May 18) 1940.

303. Wilson, M. J.; Michele, A. A., and Jacobson, E. W.: Spontaneous Dislocation of Atlanto-Axial Articulation, Including Report of Case with Quadriplegia, J. Bone & Joint Surg. **22**:698-707 (July) 1940.

of a Thomas collar. [ED. NOTE: Prolonged rest in bed followed by substantial ambulatory fixation is important in these cases.]

Hanflig and Schlosberg [304] present a case of spontaneous dislocation of the atlantoaxial joint. They emphasize the fact that atlantoaxial dislocation must be thought of in the examination of any torticollis that occurs in a patient who also has infection in the cervical region of the spinal cord or in the vicinity.

It is important to note that long delay in making the diagnosis does not render a satisfactory reduction impossible. In this case dislocation had existed for almost ten months before it was satisfactorily reduced, and then this was accomplished by manipulation. The reduction has persisted for three and a half years.

Hall [305] presents 13 cases with histories and roentgenograms of fractures of the lower cervical and upper thoracic spinous processes. The term "clay shoveler's fracture" is applied to this fracture as it usually occurs in laborers while throwing up a shovel of clay. The clay sticks to the shovel; the worker then feels a stabbing pain and sometimes hears a crack between the shoulders and is unable to continue working. The site of fracture is most commonly the spinous process of the seventh cervical vertebra, but it ranges from the sixth cervical to the third thoracic vertebra. One symptom is pain between the shoulders, nearly always on one side of the midline and capable of being made worse by stretching the arm. The pain may go to the head down the spine or even down the arm. Pain and tenderness and motility at the site of the fracture are present The treatment indicated is early removal of the detached fragments. [ED. NOTE: This is an interesting and unusual fracture. One of us (H. E. C.) recently had such a case, in which the fracture had been unrecognized by the attending physician and diagnosed as sprain of the neck. It is our experience that this fracture is healed by rest with strapping or other means of support and does not require surgical intervention.]

Eastwood and Jefferson [306] state that the common causes of injury to cervical vertebrae are motorcar accidents, diving into shallow water and falling down stairs. Clinically, the cervical portion of the spine can be divided into the first two vertebrae and the last five.

Injuries in the atlantoaxial section of the spine are of two main types: injuries of the odontoid process and dislocations of the atlanto-

304. Hanflig, S. S., and Schlosberg, C.: Nontraumatic Dislocation of Atlanto-Axial Joint, New England J. Med. **223**:713-716 (Oct. 31) 1940.

305. Hall, R. D. M.: Clay-Shoveler's Fracture, J. Bone & Joint Surg. **22**: 63-75 (Jan.) 1940.

306. Eastwood, W. J., and Jefferson, G.: Discussion on Fractures and Dislocation of Cervical Vertebrae, Proc. Roy. Soc. Med. **33**:651-660 (Aug.) 1940.

axial joint. Injuries of the odontoid process may be divided into three classes: fracture of the odontoid process without displacement, fracture of the odontoid process with displacement of the atlas on the axis and displacement forward of the atlas without fracture of the odontoid process.

Diagnosis of fracture of the odontoid process without displacement rests mainly on roentgen examination; treatment consists of complete rest with the neck supported in neutral position in bed by a hard pillow or sandbag supplanted in two or four weeks by a well molded leather collar.

If death does not occur, reduction of fracture of the odontoid process with displacement of the atlas on the axis is usually easily effected through recumbency with some hyperextension. No manipulative treatment or traction on the head is necessary. Reduction should be followed by recumbency for six weeks, and then a carefully fitted leather doll's collar extending from the occiput well down the thorax should be applied. Bony union usually takes place within six months after the injury

Displacement forward of the atlas without fracture of the odontoid process is usually fatal, as the transverse ligament is ruptured without damage to the bone. For those few patients who survive, treatment differs in no way from that of fracture of the odontoid process with displacement forward of the atlas.

According to Greeley,[307] rotary dislocation of the atlantoaxial joint is a rare injury; but reduction is easily obtained with the patient under general anesthesia, and after three weeks' immobilization free use of the cervical part of the spine is permitted. Eastwood and Jefferson obtained good results by treating a 17 year old youth by recumbency for ten days with gentle traction.

Injuries of the lower five cervical vertebrae are usually divided into three types: fracture, dislocation and fracture-dislocation.

When a diagnosis of fracture is made, it is usual to give treatment in hyperextension if the injury is a compression fracture of one of the bodies and in a neutral position if the injury consists of a fracture of the neural arch without displacement.

According to Langworthy, dislocation may be bilateral or unilateral, and symptoms referable to the spinal cord are entirely absent with unilateral dislocation. The mortality rate of bilateral dislocation is high; symptoms referable to the spinal cord are present in 50 per cent of the cases. There are two methods of treatment: immediate reduction with the patient under general anesthesia and slow, gradual replacement by

307. Greeley, cited by Eastwood and Jefferson.[306]

traction. After reduction there may be recurrence unless immobilization is maintained for at least two months.

Fracture-dislocation has the highest percentage of symptoms referable to the spinal cord and the highest mortality. The commonest sites are the fifth, sixth and seventh cervical vertebrae. Complete dislocation of the articular process does not occur as a rule, and replacement can be obtained by gradually increasing hyperextension. If dislocation is complete, traction is essential before reduction can be obtained. [ED. NOTE: This is an excellent general outline of the diagnosis and the treatment of these serious injuries.]

Conwell [308] states that more than 50 per cent of all fractures of the vertebrae are compression fractures. This percentage is higher for fractures caused by automobile accidents. More than 70 per cent of these fractures occur at the dorsolumbar junction. Of the 13,000 fractured spines in 1937, approximately 8,000 were caused by motor vehicles. One symptom is backache of varying severity; but there may be no visible deformity and the patient may be able to walk. Conwell advises the taking of oblique roentgenograms in certain cases as well as lateral and anteroposterior views.

For corrections the author uses a modified Herzmark frame for hyperextension and places the full convexity of the frame opposite the injury. Gradual production of hyperextension is brought about until at the end of fifteen or twenty minutes full correction is obtained as evidenced by lateral roentgenograms. The patient is kept on the frame for four to six weeks, and then a snug-fitting body cast is applied. Hyperextension is still maintained for five or six weeks more. If roentgenograms show that union and a satisfactory position are developing, a Taylor back brace is substituted until complete restoration of the crushed vertebra is accomplished. Contraindications of this treatment are definite fracture or fracture-dislocation in the posterior arc and separation of the anterior common ligament from the anterior part of the body of the vertebrae. The author has observed paralytic ileus and renal calculi as complications of compression fractures of the spine.

Parnall [309] suggests a method of reduction and fixation of compression fractures of the spine that is a simple, inexpensive and convenient means of producing hyperextension. Two strips of spring steel 1 inch (2.5 cm.) wide and 30 inches (76 cm.) long are placed on both sides of the spinal column; a wide metal band is slid under the point of injury and suspended above by a block and tackle. Sand bags are placed under

308. Conwell, H. E.: Compression Fractures of Spine, Mississippi Doctor **18**:183-189 (Sept.) 1940.

309. Parnall, E.: Simple Method of Reduction and Fixation of Compression Fractures of Spine, J. Bone & Joint Surg. **22**:1072-1074 (Oct.) 1940.

the shoulders and buttocks to steady the patient. The cast can be applied in the usual manner, and the strips are easily slipped out. Contraindication for this treatment is a fracture of the posterior arc at the point of fulcrum desired. [ED. NOTE: The complication of ileus following the application of a body cast for any vertebral fracture or fractures, especially when it is necessary to bring about rather marked hyperextension, should always be kept in mind. Grave results will occur in some cases if the cast is not immediately removed. When ileus does occur, relief is usually obtained by turning the patient over on his abdomen and using routine surgical procedures.]

Furst [310] attempts to evaluate the probable significance of the mechanical factors in the production of fractures of the vertebrae after the administration of metrazol therapy. He points out that the anatomic nature of the thoracic region of the spine may explain the frequency of fractures of the fifth, sixth and seventh thoracic vertebrae and that the convexity of the thoracic region is increased by the intervertebral disks, which in this region are slightly narrower in front. Since the mobility in this region is limited to 90 degrees of flexion and only 40 degrees of extension, the flexor muscles of the spine have a definite mechanical advantage over the extensor muscles. It was demonstrated in the laboratory by direct measurement that the periphery of the superior and inferior ventral margins of the fifth thoracic vertebra is crushed by a force about one third of that required to crush the body. It is further pointed out that the compression load placed on a vertebra in the tonic phase of convulsion seems of less importance than the recurrent impacts of the clonic-tonic-clonic convulsion. Furst likewise concludes that compression of the intervertebral disks may follow fracture of the thoracic vertebral bodies in 86 per cent of the cases. Invasion of the prolapsed nucleus pulposus of the disk into the spongiosa of the body of the vertebra, resulting in the formation of a Schmorl node, has been observed. The necessity of maintaining spinal hyperextension in preventing postmetrazol vertebral fractures and intervertebral disk complications after the administration of metrazol therapy is emphasized. Its use may result in reduction of fractures from 50 to 8 per cent. [ED. NOTE: This complication following the administration of metrazol therapy is too common, and the author's suggestions are timely and important.]

Friedman, Brett and Vogt [311] found that roentgenograms of the dorsal and lumbar regions of the spine of 65 institutionalized patients

310. Furst, W.: Force Required to Crush Vertebrae: Its Probable Mechanical Relation to Postmetrazol Fracture, Psychiatric Quart. **14**:397-402 (April) 1940.

311. Friedman, E.; Brett, A. L., and Vogt, E. C.: Compressions of Vertebral Bodies During Convulsive Therapy: Preliminary Note Regarding Their Prevention, New England J. Med. **222**:704-710 (April 25) 1940.

with chronic psychosis undergoing convulsive treatment showed single or multiple compressions of the vertebral bodies in 11. None of the patients with vertebral compressions had any localized complaints. Neurologic and physical examinations revealed no abnormalities.

No relation was found to exist between the number and severity of the convulsions and the incidence of compressed vertebral bodies. With 1 exception all patients were of the inactive sedentary type. There were predisposing factors in the form of kyphoses, ruptured disks and old compressions of the vertebral bodies in 4 of 13 control cases. Osteoporosis from disuse might also have been an important factor. Precipitating factors were caused by the convulsive procedures themselves. These consisted of sudden flexor activities of the muscles of the trunk, which predominated over simultaneous extensor movements. The already fixed flexed posture of the dorsal region of the spine accentuated by the sag of the bed during treatment seemed to bring about a convergence of the acting muscle forces on the arched portion of the dorsal region of the spine, where all the compression injuries were found. Employing the knee support of a standard surgical bed as an adjustable vertebral hyperextension frame prevented compression injuries of the vertebrae in 16 consecutive cases.

Compound Fractures.—Orr [312] states that for any method of treatment of compound fractures to be effectual it must not neglect the absolutely essential fundamentals of immediate reduction of the fracture, drainage of infected wounds, immobilization in correct position and control during repair of the fracture. Restoration of the circulation and nerve supply and provision for rest to favor physiologic function in injured and inflamed parts must not be neglected as they were in the World War. He recalls a program which he proposed in 1923; it consists of the following measures:

1. Relieve the shock and reduce the fracture immediately by adequate traction.

2. Institute complete débridement and drainage. (He advises use of iodine and alcohol to swab out the wound.)

3. Use nonabsorbent, nonirritating petrolatum packing to fill the wound; this protects the surface and allows permanent drainage.

4. Enclose the entire limb in a plaster of paris cast with whatever fixation is necessary.

5. Wait until the patient's condition warrants the removal of the severely injured limb if indicated; pain and shock, however, should be relieved beforehand.

6. Finally, do no postoperative dressings.

312. Orr, H. W.: Treatment of Compound Fractures, with Special Reference to Military Surgical Procedures, Arch. Surg. **40**:825-837 (May) 1940.

He then points out six misconceptions which must be laid aside if such a program is to be followed. The experience of the author and of other competent observers who employed these principles in more than 10,000 cases in the Spanish civil war shows that good results may be obtained by the infrequent dressing method with 85 to 90 per cent of compound infected fractures of all kinds. [ED. NOTE: No one treatment is applicable to all compound fractures in military and civilian life. Orr has, however, presented some excellent principles to be used in certain compound fractures (infected) occurring under certain conditions.]

Trueta and Barnes [313] point out that hitherto the efforts of surgeons in the treatment of infected wounds have mainly been directed toward destroying bacteria by the use of antiseptics. Far too little attention has been paid to the natural powers of the tissue to localize and kill bacteria. Application to the wounds of an antiseptic that will kill bacteria will damage the tissue and disturb the injured parts.

The method of treating infected wounds in a closed plaster cast is based on entirely different principles and appears to offer a solution to the problem. The essential points are cleansing the wound with soap and water, performing thorough débridement, insuring adequate drainage by opening up all deeper tissues and completely immobilizing all soft tissue by enclosing the injured part in a plaster cast. The healthy tissue underneath presents an absolute barrier to the entry of bacteria into the general circulation.

For freshly infected wounds they advocate thorough excision of all dead tissue and complete immobilization of all soft tissue not only of the joints but of the entire limb. This prevents the flow of lymph and minimizes the absorption of bacteria from the site of the wound. With wounds that have been present for twelve hours or more, complete immobilization of the inflamed wound will reduce the chances of bacteria passing out of the inflamed area into the circulation. The closed plaster technic is employed for wounds in the process of healing. The wound is left undisturbed for days or even weeks at a time; thus the granulation tissue can act as an effective barrier to infection. [ED. NOTE: One of us (H. E. C.) disapproves the authors' technic for treating fresh wounds. Here again a thorough débridement with mechanical cleansing and the application of sulfanilamide with immediate closure of the wound without a plaster cast are in most instances the most favorable treatment.]

313. Trueta, J., and Barnes, J. M.: Rationale of Complete Immobilization in Treatment of Infected Wounds, Brit. M. J. **2**:46-48 (July 13) 1940.

Baillat [314] describes his experiences with the treatment of fractures by immobilization in occlusive plaster casts in the recent Spanish civil war and states the method is known as the "Spanish method." He writes that Trueta in a hospital in Barcelona found it satisfactory where supervision and primary surgical treatment had been adequate. The treatment consists of reduction by an extension apparatus and immobilization in a plaster cast. The first plaster cast was left in place for ten to fifteen days and the second for twenty to thirty days; the third was left in place for one month. Infected tissue was usually not left in the fracture area; if it was, the plaster cast was opened to insure drainage. Amputation was necessary in only 1 of 615 cases. Functional results were usually satisfactory. Pseudarthrosis developed in 3 cases because of excessive loss of tissue. Stiffness of the joints, especially in the knee or elbow, resulted in a few cases. There were only 2 cases of complete ankylosis.

Baillat has used this method in his ordinary practice as well as in the treatment of war wounds in the Spanish civil war. The results after appropriate operation were good in the majority of cases. He is convinced of its definite value in the treatment of war wounds. [ED. NOTE: It is difficult to truly evaluate the final results of this treatment in view of the type of warfare which has been and is being carried on in the European countries. Under war conditions, which in most instances were and are chaotic, this treatment is probably efficient in many cases and most of the time is the only way out. It is, however, difficult to see how this treatment is superior to other methods of treatment and should be advocated when more favorable surroundings and a well trained staff with the proper equipment are available, whether the situation occurs in regular practice or under war conditions.]

During the Spanish civil war, d'Harcourt, Folch Pi and Oriol Angeura [315] were personally responsible for the treatment of 7,500 fractures, and they followed up 17,000 patients treated in other centers. As a result of their experience, they extended the closed plaster method of treating fractures to the treatment of injuries of soft tissues in cases in which there was much loss of substance. The method was used both at an early stage (within six or eight hours after the infliction of the wound) and at a later stage, when the wound had already begun to granulate. Only slight variation in technic was required for the two types. The technic permits a great deal of conservative treatment. In

314. Baillat, G.: Therapy of War Fractures by Occlusive Plaster Apparatus, Rev. d'orthop. **26**:656-663, 1940.

315. d'Harcourt, J.; Folch Pi, A., and Oriol Angeura, A.: Closed Plaster Method of Treatment: Account of Its Use During Spanish War, Brit. M. J. **1**:652-654 (April 20) 1940.

the battle of the Ebro a surgical unit dealt with 120 casualties, and in only 5 cases were amputations necessary. At the Vallcarca Hospital in Barcelona, 5,000 wounded were treated in one year (the wounds were fractures almost exclusively); secondary amputations were performed on only 26 of these, and few serious complications were encountered. There were 20 cases of gas gangrene; in 12 of these there were vascular lesions. The number of deaths among the 5,000 patients was 27; of these 15 were due to gas gangrene, 17 to septicemia and 5 to secondary hemorrhage. There were no instances of nonunion or malunion from faulty position of the fragments, although in a number of comminuted fractures many broken pieces of bone had lost all nutrient connection.

In a few cases nonunion occurred in the forearm, the result of extensive loss of substance. Osteomyelitis complicating fractures was not serious, but it was persistent. The closed method of treatment did not have any definite detrimental or beneficial effect on this complication. The method reduces the period of healing, particularly that of the preliminary state of disintegration. The strict immobilization of the wound insures a faster growth of epithelium and prevents the distribution and absorption of products of disintegration which would occur with constant handling. The method does not interfere with the natural process of healing, which would be disturbed by the application of antiseptics. Proteolysis does not occur. Dehydration due to evaporation at the surface of large wounds is considerably reduced, and this in itself is an important factor in the healing of the wound and the restoration of the patient's health.

Key and Burford [316] point out the great decrease in the incidence of infection after the implantation of sulfanilamide in compound injuries and emphasize that the wound must also be débrided and cleansed in the usual manner. They performed a series of experiments to determine whether sulfanilamide inhibits the healing of bone. They fractured one bone of each foreleg in a group of rabbits, implanted sulfanilamide on one side and left the other side as a control. In one group of dogs, the ulnas were fractured, and all dogs received sulfanilamide by mouth. In a second group of dogs the ulnas were fractured, and sulfanilamide was not administered. All wounds healed by primary intention, and the sites of fracture were examined microscopically and roentgenologically at intervals. No difference in the degree and rate of bony union was discovered in any group. [ED. NOTE: This report of Key and Burford presents reliable information and a valuable contribution

316. Key, J. A., and Burford, T. H.: Local Implantation of Sulfanilamide in Compound Fractures: Its Effect on Healing, South. M. J. **33**:449-455 (May) 1940.

on the use of sulfanilamide in fractures and wounds of the soft structures. Too much emphasis cannot be placed on this adjunct treatment to the true and tried mechanical cleansing and débridement of the wound and compound fracture.]

Cannaday [317] presents the following advantages of primary closure of compound fractures:

1. The period of hospitalization is shorter.

2. After healing, the injured limb is left in a much better condition. If the treatment is successful, the limb is covered with relatively normal skin rather than with a large area of scar tissue of low vitality.

3. The loss of time and the expense of care can be kept down to a reasonable minimum. However, the technic can be carried out successfully only by a surgeon thoroughly trained in this class of work. It requires a most scrupulous asepsis and meticulous attention to detail. The author performs a careful débridement with irrigation of the wound with warm saline solution. Primary closure is done with the aid of relaxing lateral incisions when necessary. The author does not favor the use of internal fixation for compound fractures. [ED. NOTE: This paper emphasizes a technic which should not be neglected, even when sulfanilamide is used. The author's main ideas have been espoused by many others for the last quarter of a century or more. No surgeon can expect that his patient will be 100 per cent free from infection. However, in view of the inevitable percentage of infection in using the author's technic, what objection could there be to using sulfanilamide to try to reduce infection? Internal fixation is indicated in certain compound fractures, and when indicated, it should be used.]

Reynolds, Zeiss and Cubbins [318] state that the specific aim of their report is to investigate the incidence of wound infection in compound fractures in two groups of patients. One group was treated by sharp débridement, followed if necessary by cleansing the interior of the wound with copious floodings of bland solutions, such as saline solution or soft soap U. S. P. followed by saline solution. For the second group practically the same routine was utilized, but iodine and alcohol were introduced into the depths of the wound after débridement. A study of 131 consecutive cases of compound fracture was made. The authors emphasize that no 2 cases were alike in extent of injury or amount of contamination and that there was also a difference in the general condition of the patients. The large percentage of deaths (31) is accounted

317. Cannaday, J. E.: Primary Closure of Traumatic Wounds with Especial Reference to Conversion of Compound into Simple Fractures, Am. J. Surg. **47**:375-390 (Feb.) 1940.

318. Reynolds, J. T.; Zeiss, C. R., and Cubbins, W. R.: Compound Fractures, Arch. Surg. **40**:844-852 (May) 1940.

for by the poor general condition of the patients when admitted. An analysis of 88 cases is presented, in half of which the wounds were flooded with iodine and alcohol before cleansing and in the other half of which only a bland solution followed by saline solution was used. Infection developed in 18.1 per cent of the patients treated with iodine and alcohol and in 13.1 per cent of the others. The greater number of infected wounds in those cases in which iodine and alcohol were used is explained on the assumption that the iodine causes death of a sufficiently large number of cells to allow infection to take place. [ED. NOTE: This is another demonstration that débridement and mechanical cleansing of the wounds are more important than the saturation of a wound with antiseptics. This statement, however, is not in condemnation of the use of sulfanilamide after proper mechanical cleansing and débridement of a wound or compound fracture.]

McKee [319] outlines a quick and simple method of treating compound fractures of the leg by the use of a special apparatus he employs. McKee feels that his technic will prove of value when large numbers of compound fractures have to be dealt with at the same time. The apparatus consists essentially of clamps by which Steinmann pins can be fixed to the side bars of a Thomas splint. Details of the treatment are given, and the after-treatment is described. The method is quick, easy, safe and effective. It is eminently suitable for immobilizing compound fractures of the leg under war conditions.

Multiple Fractures.—Hudson [320] reports 30 cases of multiple fractures involving two or three extremities which were accompanied by fractures of the pelvis, the spine, the ribs, the skull or the face but were not complicated by intra-abdominal lesions.

Hudson uses the following method of treating these patients: The patient who is in shock of some degree varying from moderately severe to extremely severe is immediately given a hypodermic injection of a mixture of $\frac{1}{100}$ grain (0.0006 Gm.) of scopolamine, $\frac{1}{4}$ grain (0.015 Gm.) of morphine sulfate and cactin. No inhalation anesthesia is used or needed. Although the procedure may be painless with only this mixture, the additional measure of infiltration with procaine hydrochloride may make it completely so. Hudson uses this medication in all cases of trauma requiring early operation. Patients with fractures of the skull may be treated by this procedure. The patient is placed in the shock position. An intravenous injection of 1,500 cc. of 5 per cent dextrose in saline solution is given. Roentgen examinations are then made with a portable

319. McKee, G. K.: Treatment of Compound Fractures of Leg, Lancet **2**:38-40 (July 13) 1940.

320. Hudson, O. C.: Multiple Fractures, J. Bone & Joint Surg. **22**:354-360 (April) 1940.

machine. The extremities are shaved without removing the temporary immobilization. One hour is allowed for the maximum effect of the hypodermic injection to take place. Treatment is instituted by a trained team, compound lesions are débrided, and fractures are then reduced and immobilized with their permanent fixation dressing. The patient is returned to bed and the foot of the bed elevated. A transfusion is given.

Immobilization is maintained until complete osseous healing has occurred. Active muscle exercises of all nonimmobilized joints and of all immobilized extremities are done hourly from the day of injury until the patient is discharged. The tendon sense is maintained, and stiffness and atrophy of the joint are prevented. The mortality rate is rather high. Hudson treats every patient that is not moribund on admission as if he would recover. The condition of the patient who dies within one to twelve hours after admission is usually hopeless from the beginning. Since adopting this method of treatment, Hudson has found that the patient was more comfortable owing to complete immobilization of the fractures; the shock was less, and the recovery from shock was shortened to between twelve and twenty-four hours. The end results were better anatomically and functionally. [ED. NOTE: It is gratifying to note the increasing interest being manifested in the early care of the injured. Surgeons should learn to perfect themselves in this care before expecting the public to know what to do. It behooves surgeons, however, to make the public conscious of certain elementary procedures in caring for those injured by accidents and thereby to prevent many unnecessary disabilities and, in many instances, even death.]

Skeletal Traction.—Mathewson [321] states that skeletal traction, long considered feasible by surgeons, had to await the introduction of aseptic surgery for its safe and full application. He points out the complications which may arise in the wake of enthusiasm for all types of skeletal traction from the misuse rather than the application of the method. The greatest danger is infection, which may result from the use of improper technic at the time of application or from the subsequent motion of the metal agent used for traction. The latter is particularly apt to lead to infection if the direction of motion is along the axis of insertion. This will not occur at first, as the nail or pin is embedded in the bone. Later, as traction is applied, aseptic pressure necrosis takes place, and the nail becomes loose. To prevent this the author uses metal sleeves (even these are not infallible) to fit over the skeletal traction wires (rather than Steinmann pins). These sleeves are placed firmly against the cortex of bone on either side and extend to the

321. Mathewson, C., Jr.: Misuse of Skeletal Traction, Am. J. Surg. **47**: 408-430 (Feb.) 1940.

spreader or stirrup. The same result can be obtained by incorporating the traction wires in a plaster cast.

The complications of infection are most severe when a hematoma, a joint or an unrecognized linear fracture communicating with a major fracture is traversed by a traction pin. Improperly placed pins may result in inefficient traction, pressure necrosis of soft tissues or severe damage to the bone or neighboring epiphysial areas of a joint. The use of metal tongs is condemned, except for traction on the skull in fractures of the cervical part of the spine.

Aside from infection, distraction is the greatest danger associated with skeletal traction, leading to delayed union or nonunion. Too much weight over too long a period not only will cause distraction, but will stretch the musculature so that it loses its power to contract. Although distraction does occur in single point traction, its possibility is greatly increased when multiple sites of traction are used.

The ambulatory management of patients treated by the incorporation of the skeletal pins in plaster of paris casts is considered dangerous, particularly when weight bearing on the skeletal pins is allowed. [ED. NOTE: This is an excellent and timely discussion.]

X. FRACTURE DEFORMITIES

Physiologic Factors in the Healing of Fractures.—The physiologic factors concerned with the healing of fractures and the formation of callus have been the subject of much experimental and clinical study in recent years. The p_H of the fluids in the tissues near the site of the fracture has been compared to that of the blood serum, and any definite changes have been noted. Achlorhydria has been observed as a depressing influence, or at least a frequent accompaniment of delayed union in fractures.

Tollman, Drummond, McIntyre and Bisgard [322] conducted an experimental study of tissue metabolism and phosphatase activity in early formation of callus. Adult rabbits in which experimental fractures of the radius had been produced by osteotomy were used. Blood was removed before and after death for determination of the phosphatase content. After three or four days callus was removed for the study of metabolic activity. It was observed that there was a general falling off in metabolic activity as the age of the callus increased; the authors felt this was due to decreased activity of the tissue. Calcification showed a general increase with age of the callus, but there was variability. On microscopic examination specimens with a high calcium content showed

322. Tollman, J. P.; Drummond, D. H.; McIntyre, A. R., and Bisgard, J. D.: Tissue Metabolism and Phosphatase Activity in Early Callus, Arch. Surg. **40**:43-48 (Jan.) 1940.

the best developed bone, with formation of well defined spicules. The phosphatase activity was relatively low at the start but rose with active proliferation of bone. There was a close correlation between the amount of calcification and the amount of phosphatase activity. The authors found that the degree of healing in the early stages was dependent not so much on the age of the fracture as on the amount of phosphatase produced. This was shown in 1 rabbit which became infected and was killed on the seventh day. The phosphatase activity was about one-tenth that observed in another rabbit which was uninfected and was killed the same day. The amount of calcification was also less.

No definite shifts in the values for blood phosphatase were observed. There was an initial rise in tissue metabolism of the callus, followed by a fall. There was an irregular increase in phosphatase activity and calcium deposition with time. The changes in concentration of serum phosphatase were not characteristic. A close relation was found between the phosphatase activity of the callus and the amount of calcium deposition.

Pollock,[323] impressed by the frequency of central fractures of the neck of the femur and atrophic spondylitis in elderly women as compared with men in the same age groups, thought there might be some relation between this fracture and the cessation of ovarian function.

In searching for experimental confirmation of his impression that estrogen influenced calcification, a study was made of the production of callus and healing of bone in a series of experimental fractures in rats. Normal adult female rats, adult female rats spayed at three months for other experimental work and young female rats spayed just before the present experiment were used. After experimental fractures had been produced, large doses of estrone (theelin) were given to two groups and withheld from the others. The following observations were made after operation:

In group A, or that which corresponded to healthy, nonspayed rats, callus was present in 2 of the 4 survivors (50 per cent) by the end of the third week following fracture. In group B, in which the rats had been spayed, no callus was found at the end of twenty-one days, whereas in group C, in which the animals were spayed and then treated by huge doses of theelin, calcification was present in 50 per cent by the fourteenth postoperative day and in 75 per cent by the twenty-first postoperative day at its lowest estimation.

In the younger age groups, confirmatory findings were obtained. In group E in which theelin was not given, callus was not present by the end of the fourteenth day. By the end of the twenty-first postoperative day, callus was present in one with a faint possibility of some being present in a second rat. In group D in which theelin was given, 50 per cent showed the presence of callus by the end of the fourteenth postoperative day and 75 per cent by the end of the twenty-first day after operation.

323. Pollock, G. A.: Effect of Theelin on Fracture Repair. Proc. Staff Meet., Mayo Clin. **15**:209-214 (April 3) 1940.

Pollock concludes that the results which followed the administration of estrone were sufficiently striking to indicate that ovarian secretion influences calcification and in cases of fracture may accelerate solid union.

[ED. NOTE: This interesting piece of experimental work probably has little practical therapeutic value at present. While the cessation or the depression of ovarian function apparently is a contributing cause of senile osteoporosis, dysfunction of the entire endocrine system is involved in the problem. Many patients with senile osteoporosis and delayed unions in fractures have been treated with large doses of estrone over prolonged periods, but no increase in calcification has been demonstrated roentgenologically and no acceleration in union of the fractures has been noted.]

Calcification in the Soft Tissues Adjacent to Fractures.—The deposition of calcium in hematomas, muscles, ligaments and tendons adjacent to fractures or associated with simple traumatic injuries of joints is a well recognized condition. The physiologic or pathologic processes producing such deposition have not yet been satisfactorily explained. The amount of soft tissue injured or the extent of the hematoma does not have any influence. Brumbaugh [324] discusses the problem and reports 3 cases of calcification resulting from injury to tendinous and ligamentous tissue of the elbow, the knee and the shoulder. The exact process by which traumatized tendon fibers calcify and often later ossify has not been clearly demonstrated, and the author does not add to the knowledge. He states that Callen's [325] conclusion regarding Pellegrini-Stieda disease is justified, namely, that this particular condition is not a disease entity but represents a local manifestation in the knee of post-traumatic changes common to other joints. He believes that the processes in the three joints, as illustrated by his cases, are identical.

Atrophy of Bone.—One of the distressing aftermaths of the treatment of fractures may be excessive atrophy of the bone. Jordan [326] emphasizes some measures in the after-care of fractures which can prevent this. He stresses the importance of instituting physical therapy immediately after reduction and immobilization. He states that overstretching is often an important and overlooked cause of atrophy of muscle. In determining the best position for immobilization, the effect of that position on all the muscles acting on all the joints of the extremity is to be considered. The author believes that mechanical factors play a

324. Brumbaugh, H. L.: Calcifying Tendinitis Traumatica: Diagnosis and Treatment of Post-Traumatic Changes In and About Joints, Am. J. Surg. **48**:681-684 (June) 1940.

325. Callen, H. S.: Pellegrini-Stieda's Disease: Manifestation in Knee of Post-Traumatic Changes Common to Other Joints, Radiology **29**:158-165 (Aug.) 1937.

326. Jordan, H. H.: After-Care of Fractures with Special Reference to Delayed Union and Sudeck's Atrophy, Arch. Phys. Therapy **21**:25-32 (Jan.) 1940.

dominant role in nonunion. Frequently, the union is not actually delayed but the period of immobilization is too short. To overcome the fear of prolonged immobilization, he emphasizes that stiffness of a normal joint will not occur from fixation in a normal position no matter how long continued, especially if the whole extremity is immobilized. Complicating the after-care of the fracture may be an acute atrophy of bone (the so-called Sudeck atrophy). Although Sudeck now believes this condition to be a physiologic reaction to trauma, Jordan points out that the typical mottled appearance in the roentgenogram is accompanied by pain and disability, which require treatment. He believes that weight bearing and exercises in unpadded plaster casts are the most effective form of treatment.

Ghormley [327] discusses post-traumatic painful atrophy of joints and distinguishes this as a clinical entity from Sudeck's atrophy and from atrophy of disuse. The usual picture is that of a sprained ankle or knee relieved by rest and immobilization; the patient then resumes activities, and gradually pain and swelling appear in the affected joint; the patient then finds relief again in immobilization, but again experiences difficulty with renewed activity. Thus a vicious circle is set up. Treatment is based on gradually increasing and constant exercise. Massage, at first light and then heavier, is used and followed by carefully planned active exercise. The latter is the most important phase. Weight bearing is begun with crutches after confidence is acquired. By this regimen normal activity is usually established in three months, but complete restoration to normal may require several more months. The author believes that sympathectomy is not indicated, because all patients will recover with properly supervised conservative measures. Supplements of calcium and vitamin D to the diet are worth while.

[ED. NOTE: Jordan and Ghormley's articles, although presenting little new, emphasize important factors in the treatment and prevention of an unlooked for complication which might result in permanent disability.]

Correction by Growth of Deformities Resulting from Fractures in Childhood.—The general principle that subsequent changes with growth will correct even gross deformities due to malunion of fractures occurring in childhood must be accepted with reservations. Stimson,[328] after analyzing a group of such deformities, lays down fundamental principles to be used as guides in determining whether or not to correct certain deformities resulting from fractures in childhood.

---

327. Ghormley, R. K.: Post-Traumatic Painful Atrophy of Joints, Arch. Phys. Therapy **20**:725-731 (Dec.) 1939.

328. Stimson, B. B.: Growth Correction of Deformities Resulting from Fractures in Children, S. Clin. North America **20**:589-592 (April) 1940.

First, the younger the child the better the eventual correction will be. Fractures occurring during delivery, especially in the shafts of long bones, heal remarkably well and gross displacements correct themselves over a relatively short period of time. Large masses of callus are quickly formed about the ends of the fragments, and even though the ends of the bones are widely displaced, a new shaft will be fashioned from this mass of callus as it condenses. This assumes the contour, the alinement and usually the approximate length of the normal shaft. Any deficiencies in length are made up by compensatory overgrowth. Splinting, sufficient to immobilize temporarily and maintain approximate alinement, is all that is required.

A second fundamental principle is that growth will tend to correct the displacement in complete transverse fractures of the long bones if the axes are maintained. The author feels that "operative interference in these cases is not justified unless there is interposition of soft structures or evidence of severe circulatory or nerve damage." [ED. NOTE: Circulatory or nerve damage rarely occurs in children in connection with fractures, except supracondylar fractures at the elbow. In most instances manipulative correction of the gross deformity at the site of fracture is also sufficient to care for circulatory or nerve complications. Early operative interference in threatened or established Volkmann's ischemic paralysis has been advocated in articles by several other authors; the practical value of such procedures appears doubtful. The indications for the necessity of the operation are indefinite and difficult to determine in the early stage. In most cases a decision based on the initial symptoms would subject the patient to an unnecessary operation and complicate the treatment of the fracture. On the other hand, if the decision to operate is delayed until the condition is evident, it is too late to accomplish any material benefit.]

A third fundamental principle is that, in angular deformities, the outline will tend to become rounded out, converting the sharp angle into a curve rather than resulting in a straight bone.

In certain locations this may result in disability. The disability appears to depend on two factors: the direction of the bowing and the site of the fracture. This is best shown in fractures of the forearm. Dorsal bowing resulting from fractures in which the distal fragment is tilted volarward interferes with rotation less frequently than volar bowing. Fractures in the middle portions of the shafts permitted to heal with deformity are more likely to result in disabilitiy than those in the lower third. Fractures of the lower end of the radius united with either dorsal or volar angulation often show little, if any, correction from compensatory growth. When this deformity exists to an appreciable extent, particularly in connection with dorsal angulation, it may produce disability and should be corrected.

The question of compensatory overgrowth in the shaft of the femur after fracture in children has been carefully analyzed by Aitken.[329] He presents a study of the end results in 71 cases of fracture of the femoral shaft in children under 16 years of age. The patients have been followed

329. Aitken, A. P.: Overgrowth of Femoral Shaft Following Fracture in Children, Am. J. Surg. **49**:147-148 (July) 1940.

from three months to eight years and are divided into two age groups: one 13 years of age or older and the other 12 years of age or younger. In the older age group are 6 patients with an average period of five years since fracture. All fractures either were anatomically reduced or had lateral displacement without shortening. In 5 cases an average shortening of 1 cm. is present. One patient, 13 years of age at the time of the fracture, has a lengthening of 1.6 cm.; the epiphyses are closed, so the lengthening is permanent. In the group 12 years of age or younger there are 65 patients. In this group all but 1 show lengthening of the femur from the position on discharge. In 9 patients anatomic reduction was obtained. In 1 there is no difference in length, while in 8 the fractured femur averages 1.1 cm. longer. Seven patients were discharged with lateral displacement but no shortening; these show an average lengthening of 1.1 cm. One patient, whose limb was overpulled by 0.7 cm., now has lengthening of 1.7 cm. In 8, open reductions were performed, and anatomic position was maintained in 4; in these, the femurs are now 1 cm. longer. In 4, bowing occurred, shortening the femur an average of 0.8 cm.; these have an average lengthening of 0.8 cm., making an average overgrowth of 1.6 cm. Thirty-eight patients were discharged with complete displacement and overriding. In 21 patients, the fractured femur is longer than the sound one. In 9 patients, the average shortening was 1.2 cm. and the average length is now 0.4 cm., an average overgrowth of 1.6 cm. In 12 patients on discharge, a shortening of 0.6 cm. was present; there is now an average lengthening of 0.7 cm., an overgrowth of 1.3 cm. In 17 patients, there is still some shortening. In 11 patients, the average shortening on discharge was 1.3 cm., and final shortening was still 0.5 cm. In 6 patients the average shortening was 0.6 cm. and is now 0.2 cm. It is noted that the patients showing the most shortening on discharge now show the most overgrowth. The greater the displacement, the larger the callus and the longer it persists.

Overgrowth of 1 cm. occurred in 2 patients with pathologic fractures. In 9 patients with fractures over one year old and in 2 patients with fractures of less than six months' duration, there was overgrowth of 0.3 cm.; in 7 patients with fractures of six months' to one year's duration the average overgrowth was 1 cm. Overgrowth occurs while callus is still present. The type or site of the fracture made no difference. The author believes the overgrowth is due to periosteal stimulation resulting from periosteal hyperemia. He doubts that the overgrowth is balanced by the time of epiphysial closure and cites 9 cases in which this has not occurred.

[ED. NOTE: Fractures and dislocations involving the epiphysial growth lines may frequently produce disturbances in future growth with the development of varus or valgus deformities of the adjacent joints or

shortening of the shaft. The subsequent disturbance in growth does not depend solely on the amount of apparent damage to the epiphysial line. Some patients with simple fracture running transversely across the epiphysial line without displacement will show retardation of growth with deformity. On the other hand, in certain complete epiphysial separations, such as that of the lower end of the radius, which have not been reduced and have united without contact between the epiphyses and the shaft, normal length and alinement of the bone are the usual result.]

Treatment of Malunited and Ununited Fractures.—Fractures of the distal ends of the metacarpal bones, "knuckle fractures," are commonly regarded as trivial injuries, and the treatment given in many instances is inadequate to prevent crippling deformity. When such deformity occurs in the first, second or third metacarpal bone, function in the fingers may be severely impaired for occupations requiring accurate coordination of finger movement.

Although many methods of closed reduction and splinting have been described, the consensus of most surgeons is that none of them are dependable to reduce and maintain the proper position of the fracture. The usual result is a malunion with the head and articular surface of the metacarpal articulation angulated and depressed toward the palm of the hand, with shortening of the metacarpal and limitation of flexion of the finger.

Haboush [330] presents the regional anatomy and pathology of fractures of the knuckle and describes an operation designed to restore the flexor action of the finger.

The metacarpophalangeal joints have no true capsule but are invested by a synovial sac reenforced by the tendons and two collateral ligaments. The space between the synovial sac and the extensor tendon is normally filled with loose areolar tissue. This space is important in that it makes possible a wide excursion of motion of the extensor expansion as it glides over the synovial membrane and smooth dorsal angle of the metacarpal bone. Callus or adhesions in this space limit the excursion of the extensor expansion and prevent complete flexion of the joint.

In a case described by Haboush, one of a malunited fracture of the distal end of the fifth metacarpal bone, the space just described was filled with a dense fibrous tissue resembling fibrocartilage. The extensor tendon expansion was firmly adherent to this mass, impairing flexion of the finger. Removal of this mass of fibrous tissue and of the adjacent callus and projecting edges of the fractured shaft on the ulnar side was carried out, thus diminishing the anterior posterior and lateral diameters

330. Haboush, E. J.: Malunion of Fracture of Head of Metacarpal Bone (Knuckle Fractures): Simple Operation for Correction, J. Bone & Joint Surg. **22**:1054-1058 (Oct.) 1940.

of the metacarpal bone and establishing a normal relationship with the flexor and extensor tendons.

The author states that six weeks after operation there was normal flexion in the finger.

[Ed. Note: In this procedure no attempt is made to correct the primary anatomic deformity of the fracture. It seems probable that the palmar angulation and tilting of the articular surface of the metacarpal head must contribute to the dysfunction and that any operation which does not at least partly remedy this anatomic deformity will fail to restore function, at least in the first three metacarpal bones, where functional disturbance is usually greatest.

Experience has shown that correction of malposition after union is difficult in the early stage owing to osteoporosis of the distal fragment. Later, after the bone has recalcified, an osteotomy can be performed to correct the palmar angulation and the shortening. The position is maintained by means of an intramedullary bone peg extending from the shaft into the head; the gap on the palmar surface is filled with a small bone wedge.

A better solution of the whole problem of these fractures would be to assume a more positive attitude in treating them at the time of acute fracture and to do an immediate open reduction and internal fixation with a medullary bone peg. The same conditions pertain to displaced fractures of the metatarsal heads.]

Masland [331] describes a splint to be used in the conservative treatment of nonunion in fractures of the bones of the forearm and other long bones. The operation of the splint produces continuous distraction of the bone in its normal alinement with opportunity for both flexion and rotation of the forearm. It proposes to secure by continuous distention what cannot be accomplished by immediate extension of the injured member. No statistics of the number of cases in which the splint has been used or of the end results are given.

[Ed. Note: A careful distinction between delayed union and true nonunion is essential in estimating the value of any method of treatment. With the conditions of a real nonunion present, bone grafting has proved to be the most reliable and in the end the most conservative method of inducing union.]

Abbott [332] advocates the use of manipulation and skeletal traction in a Thomas splint for the treatment of malunited and ununited fractures of the shaft of the femur. It is his opinion that operation on patients

331. Masland, H. C.: Conservative Treatment of Non-Union, Am. J. Surg. **47**: 170-171 (Jan.) 1940.

332. Abbott, L. C.: Treatment of Malunited and Ununited Fractures of Shaft of Femur by Manipulation and Skeletal Traction, Am. J. Surg. **49**:181-188 (July) 1940.

who are seen within a few months after the fracture may be avoided. Simple manipulation with freeing of the fragments in both malunited and ununited fractures, followed by skeletal traction, will often bring about union with correct alinement and full length of the limb. The simplest method of obtaining proper length and alinement without complicated operative procedures is the preferred treatment of these fractures and in the long run will yield the most satisfactory results.

The necessity of maintaining traction until the callus uniting the fracture has completely consolidated is strongly emphasized. Failure to observe this fundamental principle will often result in recurrence of the deformity. The average period of traction required for a malunited fracture of the femoral shaft is about twelve weeks.

The same principle is applied to the treatment of ununited fractures of the shaft of the femur. Manipulation of these fractures serves a twofold purpose: it disengages the fragments from a mass of fibrous tissue and callus, and by so doing it stimulates the callus to renewed activity. Union may be hastened by percussing the callus with a rubber hammer and by placing constricting rubber bands above and below the fracture site, an old method described by Hugh Owen Thomas.

The greatest difficulty encountered in the one stage operative method of treatment is to overcome the shortening of the extremity due to the overlapping of the fragments with accompanying contractions of the soft tissue. Consequently, even though some type of operation is to be employed, manipulation and skeletal traction are valuable preliminary procedures.

Henderson [333] discusses the entire problem of ununited fractures and analyzes the end results of such fractures treated by bone grafts at the Mayo Clinic up to 1936.

Patients with ununited fractures are usually in excellent general health, and no clue as to cause can be elicited by the most painstaking general examination. The causative factors in nonunion are local and not systemic. Regulation of diet and administration of calcium or of glandular extracts are of no benefit. Physiologic inertia exists at the site of fracture; this must be done away with and the process of bone regeneration initiated if union is to occur. The most dependable method of accomplishing this is the use of autogenous bone grafts.

The experience gained from a study of this large series of bone grafts has crystallized certain cardinal principles regarding the selection of cases, operative technic and after-care; the surgeon should keep them constantly in mind. They are:

1. No ununited fracture should be subjected to direct operative attack if there are any draining sinuses or if there is any latent infection in the vicinity of the fracture.

333. Henderson, M. S.: Problem of Ununited Fracture, Am. J. Surg. **47**:454-465 (Feb.) 1940.

2. Fibrous tissue should be removed from between and about the bone ends; the medullary cavities should be opened, and the ends of the bones fitted, so that they can be held in close apposition by the aid of a bone graft.

3. The graft must be long and large enough to insure large surface contact of graft with both fragments. The bone graft serves two functions, a physiologic function in stimulating formation of bone and a mechanical function in providing internal fixation.

4. The graft must be held securely to the fragments by aid of beef bone screws, autogenous bone pegs, metal screws or metal bands. Multiple chips of bone should be packed along the line of fracture and as much as possible along the line of contact of the bone graft with the fragments. The more bone that is brought to the site of fracture the better.

5. External fixation, preferably by casts, must be provided for sufficient time to protect the graft during the period of "weakness," which develops about the fourth to the sixth week. This protection is particularly necessary in cases of fracture of the humerus or femur. Three months is the earliest that external fixation can be abandoned and some sort of protection is often essential for six months from the time of operation.

6. It must be constantly kept in mind that repair of bone is always slower to be induced after it once has failed. The second attempt at repair is certain to be slower in starting, developing and finishing than nature's first attempt. Because of that fact careful supervision of resumption of function, as to time, manner and amount, is the definite responsibility of the surgeon.

Henderson reports the relative incidence of ununited fractures of various bones as follows:

In a review of the records of 583 patients with ununited fractures treated by bone grafting operation from 1912 to 1936 inclusive in The Mayo Clinic, the relative incidence as to the bones involved was as follows: tibia, 233 cases; humerus and femur, 100 each; radius alone, seventy; radius and ulna combined, forty-four; ulna alone, thirty; clavicle, five; and metatarsal, one.

The relative results in the treatment of fractures of different bones were:

In 530 cases the end results were definitely determined. The results following bone graft of the tibia were the best in that in 94 per cent of cases the fragments united. Success was obtained in the treatment of fractures of other bones as follows: the radius alone in 93 per cent of cases; the ulna alone in 89 per cent; the humerus in 86 per cent; the radius and ulna in 85 per cent and the femur in 78 per cent. Difficulties encountered in dealing with individual bones differ with the location of the fracture, be it in the upper, middle or lower third.

Le Cocq [334] describes a method of treating ununited fractures, using vitallium plates to secure stability and fragments of bone removed from the ilium to promote osteogenesis. He says the rationale of the method is based on the belief that bone grafts held with autogenous bone pegs loosen after a few weeks and permit motion at the site of fracture and

334. LeCocq, E.: Ununited Fractures of Both Bones of Forearm, Northwest Med. **39**:165-166 (May) 1940.

between the graft and the bone before union has occurred, thus increasing the percentage of failures.

[ED. NOTE: Reported statistics of authors using massive onlay grafts record bony union in about 90 per cent of cases; the failures are due chiefly to infection or extensive osteosclerosis of the ends of the fragments but rarely to loosening of the graft. The substitution of metallic screw fixation of the onlay graft, which has been adopted by many surgeons, eliminates the difficulties formerly encountered in obtaining firm fixation of the graft by means of autogenous bone pegs. Physiologically, bone grafts are better osteogenetic agents than plates, which inhibit the production of callus over the area to which they are applied. Failure of union due to fracture of the graft occasionally occurs in locations, such as the upper third of the femur, where there is great mechanical stress. In such locations the metallic plate applied adjacent to the graft or on top of it has been added and this appears to be a more desirable method of obtaining additional fixation than substitution of the plate for the graft.]

Since the earliest use of bone grafting in the treatment of ununited fractures there have been conflicting opinions about the role played by the periosteum in the process of union. Pollock and Henderson [335] in a series of experimental grafts on the femurs of dogs endeavored to throw some further light on this controversial subject. Ten bone grafting operations were carried out. In 5, the periosteum was retained; in 5, it was removed. From analysis of the end results of the experiment the authors conclude that no advantage is gained by retention of the periosteum and that removal of the periosteum results in formation of a more active periosteum from the surrounding connective tissues.

[ED. NOTE: The results of this experiment accord with the clinical data derived from a study of many thousand bone grafts employed in the treatment of ununited fractures in human beings. Most onlay bone grafts are removed without their periosteum. There is no clinical evidence to indicate that the revascularization and incorporation into the host bone of such grafts differ in any way from the assimilation of grafts in which the periosteum is retained. The high percentage of unions obtained with the use of either type (about 90 per cent) indicates that there is no essential difference in their practical application.]

In certain locations, such as the lower jaw, the problem of bone grafting for nonunion is complicated by the possibility of unavoidable infection of the operative wound. Under such conditions the usual massive onlay graft may be lost as a sequestrum before sufficient time has elapsed to effect its revascularization. Pedunculated grafts to which

335. Pollock, G. A., and Henderson, M. S.: Value of Periosteum in Grafting Operation, Proc. Staff Meet., Mayo Clin. **15**:443-448 (July 10) 1940.

the blood supply has been preserved have proved satisfactory in avoiding this complication.

Cole [336] reports a case of pathologic fracture of the mandible with nonunion due to osteomyelitis of the jaw. The lesion was treated by a pedunculated graft. The fragments were bridged by a portion of bone removed from the lower border of the jaw in front of the site of nonunion. The blood supply of the transplanted bone was maintanied by the preservation of the attachment to it of the platysma myoides muscle and the deep fascia. These structures were so freed and fashioned as to permit shifting of the graft in position with perfect ease and without tension on the nutrient tissues.

In the case reported the graft took well. Observation three and a half years later showed no asymmetry of the facial contour, and movement of the tongue was free. Cole does not believe, as some do, that from this type of graft, functional disability caused by restriction of movements of the tongue and of the muscles of the floor of the mouth will result.

[ED. NOTE: This type of graft has been used in several cases by one of us (J. S. S.) with excellent results.]

Disability resulting from fractures about the ankle is due either to malposition or to traumatic arthritis or to a combination of the two. In malunions after the usual Pott's, or bimalleolar, fracture, satisfactory restoration of alinement with preservation of motion in the ankle and good function can usually be obtained. In cases of Cotton's, or trimalleolar, fracture, in which the astragalus has been displaced backward and upward with the posterior malleolus, the results of conservative reconstructions which attempt to retain motion in the ankle have proved disappointing. The operative and manipulative trauma to the articular surfaces of the tibia and astragalus necessary to restore position of the fragments produces disabling traumatic arthritis in such a high percentage of cases that primary fusion of the ankle is the procedure of choice. Persistent disability due to traumatic arthritis of the ankle and/or of associated tarsal joints should be treated by fusion of the affected joints. Hamsa [337] outlines the chief causes of disability from fractures of the ankle and discusses the method of examination to evaluate the disability.

In a certain number of cases, resulting traumatic arthritis may be treated conservatively with surprisingly good functional results. When

336. Cole, P. P.: Pathologic Fracture of Mandible: Non-Union Treated with Pedicle Bone Graft, Lancet **1**:1044-1045 (June 8) 1940.

337. Hamsa, W. R.: Principles of Reconstruction in Ankle Malunion, Nebraska M. J. **25**:218-221 (June) 1940.

it does not respond after a reasonable period of conservative effort, an operation should be performed.

The various types of disability are classified, and appropriate surgical treatment is given. For malunion of the tibia and fibula associated with disalinement, Hamsa advises supramalleolar osteotomy and astragalectomy if both the ankle and the subastragalar joint are involved. The foot may be stabilized and alined by arthrodesis of the subastragalar and midtarsal joints if these have been injured. Ununited fragments should be removed unless their absence would decrease the stability of the ankle. Fusion of the ankle joint should be done if this alone is involved, or panastragalar arthrodesis, if all three joints are involved. Fracture of the head of the astragalus, the author believes, should be treated primarily by operative measures, that is, fusion of the astragaloscaphoid joint or, if necessary, a triple arthrodesis. For young persons conservative treatment may be tried. For fracture of the body of the astragalus he favors operative treatment, preferring arthrodesis to astragalectomy. Fracture of Stieda's process indicates surgical removal.

[ED. NOTE: Astragalectomy is undesirable for adults and should be avoided if possible.]

Nonunion of Fractures of the Neck of the Femur.—For nonunion of less than three months' duration, King [338] advises fixation of the fragments by the Smith-Petersen nail and a bone graft, taken either from the fibula or from the tibia. For patients over 60 years of age this operation is preferable to subtrochanteric osteotomy. The patient may be up in two weeks without external immobilization, although weight bearing is not permitted for six to twelve months. If the fracture has been present for more than three months, osteotomy is preferable because changes in the head of the femur are liable to follow osseous union. The author takes issue with those who feel that the use of the Smith-Petersen nail causes aseptic necrosis. He states that aseptic necrosis occurs just as frequently when the Whitman method is used; the degree of necrosis is proportionate to the amount of damage to the circulation at the time of injury.

[ED. NOTE: The method of nailing in fractures of the neck of the femur is now widely recognized as constituting a distinct advance. There is, however, a type of case in which aseptic necrosis of the head of the femur occurs with or without union. In cases of this type the procedure advocated by King has been practiced also by Gallie with good results. One of us (L. C. A.) feels that some consideration should be devoted to the Brackett procedure supplemented by nailing, drilling or bone grafting.]

---

338. King, T.: The Value of Femoral Osteotomy for Diseases and Injury to the Hip Joint, M. J. Australia **1**:253-268 (Feb. 24) 1940.

Miltner [339] describes an operation for nonunion of fractures of the neck of the femur with "live" heads. The shaft, neck and inferior surface of the femoral head are exposed through a straight lateral incision. An oblique osteotomy is made through the shaft of the femur at an angle of 45 degrees on a level with the inferior surface of the head. A portion of the inferior surface of the head is removed, and the distal fragment is displaced medially under and into the denuded surface of the head. A plaster cast is applied. This is a modification of the Lorenz procedure, differing in that it is intra-articular and that the femoral head is cut to allow contact with the raw surface of the femoral shaft. The procedure was used successfully by the author in 3 cases only.

[ED. NOTE: This technic and similar ones are becoming more popular and certainly have their place in selected cases. Surgical shock is minimized, and excellent results have been obtained in many cases.]

XI. BONE TUMORS

General Considerations.—For purposes of uniformity and clarity in the discussion of bone tumors, it is desirable that most workers in this field make every effort to use the classification prepared by the Committee of the Registry of Bone Sarcoma of the American College of Surgeons.[340] This should serve as the basis of further classification and in time permit the establishment of categories for some of the unusual bone tumors now reported individually.

Ludford [341] has studied the interaction in vitro of fibroblasts and sarcoma cells with leukocytes and macrophages. He reports a series of experiments in vitro which confirms Carrel's demonstration that cultures of leukocytes produce substances which stimulate the growth of fibroblasts and sarcoma cells. He observed that fibroblasts or sarcoma cells when grown together with cultures of leukocytes produce earlier and more extensive growth than when grown alone. Stimulation of growth occurs without actual contact. When they are grown in contact with cells from cultures of leukocytes, not only is their growth stimulated but their capacity for proteolysis is increased. In mixed cultures both kinds of cells remain in a more active functional state. This study of the interaction of these cells in vitro leads the author to suggest that macrophages and monocytes by stimulating growth and proteolytic

339. Miltner, L. J.: Operation for Ununited Fracture of Neck of Femur, J. Iowa M. Soc. **30**:9-11 (Jan.) 1940.

340. Ewing, J.: Review of the Classification of Bone Tumors, Bull. Am. Coll. Surgeons **24**:290-295 (Sept.) 1939.

341. Ludford, R. J.: Interaction in Vitro of Fibroblasts and Sarcoma Cells with Leukocytes and Macrophages, Brit. M. J. **1**:201-205 (Feb. 10) 1940.

activity of malignant cells facilitate the invasive growth of these into normal tissues in vivo.

In a study of 28 cases of bone tumor by Cade, Maclagen and Townsend,[342] determinations of serum phosphatase were made. The results support the hypothesis that the level of the enzyme in the blood serum reflects the degree of osteoblastic activity in the bones, assuming that the possibility of gross hepatic damage has been excluded. They regard the estimation of serum phosphatase as of some value in following the treatment of osteogenic sarcoma and in detecting the onset of metastases in these conditions. Determination of serum phosphatase can sometimes indicate the presence in the bones of late metastases from other organs, such as occur with carcinoma of the prostate gland, and the test is suggested as a routine procedure in treating this condition. The method of determination used was that of King and Armstrong.[343]

Hansen, Ziegler and McQuarrie [344] followed carefully the disturbance of osseous and lipid metabolism in a child with primary carcinoma of the liver. The patient was a 10 year old boy with a tumor mass in his liver, marked hyperlipemia and marked demineralization of all bones. The autopsy revealed a hepatoma with considerable destruction of the liver. In studies of metabolism over a period of two years, the authors demonstrated: marked hyperlipemia, explained on the basis of faulty function of the liver; impaired retention of calcium and phosphorus, showing a deficiency of these substances; deficiency of vitamin D (the possibility of hyperparathyroidism and destruction of bone by tumor or infection having been excluded). The calcium phosphate and calcium carbonate ratio increased. There was a definite analogy to the deficiency of calcium. The tentative conclusion is that the liver plays an essential role in osseous metabolism by means of an unknown substance.

Weber [345] states that erythroblastemia due to both destruction and irritation of the hemopoietic tissue often accompanies secondary neoplastic infiltration of the bone marrow. The blood counts show nucleated red blood cells in the circulating blood in newborn children with congenital syphilis, in von Jaksch's anemia, in fetal erythroblastosis, in Cooley's anemia, in excessive erythropoiesis from various causes, in Addison's anemia, in Lederer's anemia and in hemolytic jaundice. Erythroblastemia is valuable in differentiating secondary neoplastic

342. Cade, S.; Maclagen, N. F., and Townsend, R. F.: Serum Phosphatase in Cases of Bone Tumor, Lancet **1**:1074-1075 (June 15) 1940.

343. King, E. J., and Armstrong, A. R.: Convenient Method for Determining Serum and Bile Phosphatase Activity, Canad. M. A. J. **31**:376-381 (Oct.) 1934.

344. Hausen, A. E.; Ziegler, M. R., and McQuarrie, I.: Disturbance of Osseous and Lipid Metabolism in Child with Primary Carcinoma of Liver, J. Pediat. **17**:9-30 (July) 1940.

345. Weber, F. P.: Erythroblastemia and Its Value in Diagnosis of Neoplastic Infiltration of Bone Marrow, Lancet **1**:1077-1078 (June 15) 1940.

infiltration of bone marrow and so-called osteitis condensans ilii. In the author's opinion, osteogenic sarcoma does not lead to erythroblastemia.

Osteomas.—Schwartz [346] reviews 48 cases of osteoma of the cranium from the standpoint of roentgenology. He classifies the tumors according to anatomic location: 60 per cent were in the frontoethmoidal regions, 13 per cent in the orbitoethmoidal region and 13 per cent in the parietal region. Osteoma is usually exostotic but may be enostotic. While recognizing that the cause is unknown, Schwartz feels that growth may be stimulated by trauma. The greater the density of the tumor, the more slowly it grows.

Schwartz [347] likewise reports a series of 5 cases of osteofibroma of the cranium. The first symptoms were local tenderness and tumefaction, and in 2 cases there was a definite history of trauma in the area involved. He describes the difficulty of differentiating this tumor from hyperparathyroidism, meningioma, metastatic tumors, osteomyelitis (especially syphilitic), cavernous hemangioma and localized lesions of the early stage of Paget's disease. He recommends surgical treatment, because the results of roentgen therapy are disappointing.

Giant Cell Tumor.—In a study of giant cell tumor of bone, Jaffe, Lichtenstein and Portis [348] present a concept which can be briefly summarized as follows: The giant cell tumor of bone is not as common or as miscellaneous a lesion as has been generally supposed. Medullary fibroma or osteofibroma, medullary xanthofibroma or xanthogranuloma and certain peculiar forms of medullary chondroma, for instance, are sometimes misclassified under the head of giant cell tumor, notably as representing supposed variants of the latter. They deprecate this tendency and feel that the resemblance between the "brown tumor" of hyperparathyroidism and certain epulides, on the one hand, and the genuine giant cell tumor, on the other, is only superficial. They conceive the giant cell tumor as a neoplasm of a definite kind, arising from the undifferentiated supporting connective tissue of the marrow and composed of a more or less vascularized network of spindle-shaped or ovoid stromal cells and multinuclear giant cells. There is little collagenous differentiation and almost no evidence of ossification. They have classified giant cell tumors into three grades. They also show that a typical giant cell tumor is not likely to develop in a person below 20 years of age. There is no characteristic roentgen picture of this tumor, and they

346. Schwartz, C. W.: Cranial Osteomas from Roentgenologic Viewpoint, Am. J. Roentgenol. **44**:188-196 (Aug.) 1940.

347. Schwartz, C. W.: Osteofibroma of Cranium from Roentgenologic Viewpoint, Am. J. Roentgenol. **43**:53-57 (Jan.) 1940.

348. Jaffe, H. L.; Lichtenstein, L., and Portis, R. B.: Giant Cell Tumor of Bone: Its Pathologic Appearance, Grading, Supposed Variants and Treatment, Arch. Path. **30**:993-1031 (Nov.) 1940.

feel that a biopsy should always be done to establish the diagnosis and that "blind" irradiation based on an unverified roentgen diagnosis alone is not justifiable. They recommend that treatment be based on the grade of aggressiveness and the location of the individual lesion.

A giant cell tumor of the patella is reported by Richards, Giberson and King.[349] They have collected 16 previously reported cases of giant cell tumor of the patella. The diagnosis in their case was confirmed by microscopic study; the tumor was removed by curettage and the cavity packed with bone chips. The immediate result is reported to be excellent.

A giant cell tumor of the jaw, subperiosteal in type, is reported by Potts.[350] He finds no previous report in the literature of a subperiosteal giant cell tumor of the skull or of the jaw. Geschickter and Copeland [351] cited 22 cases of giant cell tumor of the skull or of the jaw; in all these cases the tumor arose from those portions of bone which were preformed in cartilage. They predicted that since the periosteum has osteoclastic activity, any giant cell tumor arising from bone preformed in membrane should be subperiosteal; their prediction is fulfilled in Potts's case.

Malignant changes in giant cell tumors of bone are discussed by Fell [352] in the report of 3 cases. In 2 of these there were definitely malignant changes; in the other case the tumor is still under observation. In the first case the tumor was definitely malignant five and a half years after curettement. The original tumor was in the distal third of the femur. There was evidence of metastatic sarcoma in the inguinal glands. Death occurred two months after amputation. The second case, after two curettements at ten month intervals, showed a picture typical of osteogenic sarcoma. The lesion was in the distal third of the radius. The patient was still alive at the time of writing, five months after disarticulation at the shoulder.

Osteogenic Sarcoma.—In a study on the morphogenesis of extraskeletal osteogenic sarcoma and pseudo-osteosarcoma, Binkley and Stewart [353] describe a number of tumors of soft tissue having an epithelial origin but resembling osteogenic sarcoma. From their attempts to discover morphologic changes to explain this resemblance, they conclude that the assumption of the structure of osteogenic sarcoma is the result

349. Richards, V.; Giberson, A. F., and King, D.: Giant Cell Tumors of Patella, West. J. Surg. **48**:47-49 (Jan.) 1940.

350. Potts, W. J.: Subperiosteal Giant Cell Tumor, J. Bone & Joint Surg. **22**:417-420 (April) 1940.

351. Geschickter, C. F., and Copeland, M. M.: Tumors of Bone, revised ed., New York, American Journal of Cancer, 1936.

352. Fell, E. H.: Malignant Giant-Cell Tumors of Bone, Internat. Clin. **2**:199-205 (June) 1940.

353. Binkley, J. S., and Stewart, F. W.: Morphogenesis of Extra Skeletal Osteogenic Sarcoma and Pseudo-Osteosarcoma, Arch. Path. **29**:42-56 (Jan.) 1940.

of the laying down of dense hyaline tissue, probably resulting in ischemia, and of the development of a cavernous telangiectatic type of circulation favoring stasis and consequent probable anoxemia; that is, osteogenesis is the result of the local condition. Their studies, however, fail to explain the structure of cartilage-containing mixed tumors.

Batts [354] reports an osteogenic sarcoma of the thyroid gland in a woman 71 years of age. The tumor had been present for fifty-two years. At the time of examination the basal metabolic rate was + 31 per cent. A subtotal thyroidectomy was done. In the tissues there was a "spindle-celled osteoid-osteo-fibrosarcoma" arising on an old thyroid adenoma. He cites 7 cases previously reported in the literature.

Ewing's Tumor.—Meyerding and Pollock,[355] and Clegg and Macey [356] discuss the difficulties of the diagnosis of Ewing's tumor, particularly of differentiating it from osteomyelitis. Hamilton,[357] in a more general discussion, reports 28 cases of Ewing's tumor. Three of his patients were free of symptoms after five years.

Neely and Rogers [358] have written about the roentgenologic and pathologic considerations of Ewing's tumor, contending that it constitutes an intergradation with lymphoblastoma and myeloblastic tumors on the one hand and with fibrosarcoma and osteogenic sarcoma on the other. Their conclusions are:

1. Ewing's tumor represents an arbitrary subdivision of malignant neoplasms of bone. Histologically, it cannot be considered a neoplastic entity.

2. Roentgen signs of Ewing's tumor are not unequivocally characteristic. They result from destructive and reparative processes in osseous tissue, any of which may be seen in osteogenic sarcoma, a metastatic tumor or a non-neoplastic lesion.

3. Correlation of clinical, roentgenologic and histologic data is necessary to establish the correct diagnosis and proper classification of primary bone tumors.

4. Biopsy should be done as early as possible in any case of a lesion of bone suspected of being a primary neoplasm.

---

354. Batts, M., Jr.: Osteogenic Sarcoma of Thyroid Gland: Report of Case, Am. J. Surg. **49**:390-392 (Aug.) 1940.

355. Meyerding, H. W., and Pollock, G. A.: Ewing's Tumor (Hemangio-Endothelioma; Endothelial Myeloma; Solitary Diffuse Endothelioma): Problem in Differential Diagnosis, Minnesota Med. **23**:416-423 (June) 1940.

356. Clegg, R., and Macey, H. B.: Differential Diagnosis of Destructive Lesion of Long Bone: Report of Case, Proc. Staff Meet., Mayo Clin. **15**:317-319 (May 15) 1940.

357. Hamilton, J. F.: Ewing's Sarcoma (Endothelial Myeloma), Arch. Surg. **41**:29-52 (July) 1940.

358. Neely, J. M., and Rogers, F. T.: Roentgenological and Pathological Considerations of Ewing's Tumor, Am. J. Roentgenol. **43**:204-210 (Feb.) 1940.

Willis [359] discusses metastatic neuroblastoma presenting the Ewing syndrome and Ewing's sarcoma. He has had personal experience with 2 cases of bone tumor in which the diagnosis of Ewing's sarcoma was made on the basis of adolescence of the patients, a fusiform tumor, an onion skin lamination of the bone observed on roentgen examination and radiosensitivity of the tumor. Both these tumors proved to be secondary to neuroblastoma. The author reviews some recent publications on Ewing's tumor and concludes that the subject is chaotic, that the occurrence of a primary growth of bone of this nature is unproved and that metastatic growth of the type described will probably prove responsible in many cases.

Myeloma.—A case report of plasma cell myeloma needs consideration because of its infrequency. King [360] reports a solitary plasma cell myeloma of bone which existed for five years in the trochanteric region of the right femur before the onset of symptoms of multiple osseous lesions. Multiple myeloma was the final diagnosis.

A plasma cell myeloma in a child 9 years of age is reported by Gordon and Schneider.[361] They report the growth as representing one extreme of a series of multiple myelomas; at the other end of this series there was a typical multiple myeloma showing nodular involvement of the bony skeleton. They state that plasma cell myeloma may occur without any of the signs of multiple myeloma and that the diagnosis at this stage depends on the examination of the blood and on the microscopic examination of the sternal marrow.

Plasma cell myeloma of the eleventh thoracic vertebra with intraspinal epidural extension is reported as a Cabot case.[362] Laminectomy at the level of the eleventh thoracic vertebra demonstrated a dense tumor in the epidural space. The laminas of the eleventh dorsal vertebra were soft and infiltrated by the tumor, which on microscopic examination proved to be a plasma cell myeloma.

In another Cabot case [363] the autopsy showed multiple lesions of a lymphoblastic myeloma with extensive involvement of the skeletal system and also multiple foci of tumor growth in the cortex of the kidney. In

359. Willis, R. A.: Metastatic Neuroblastoma in Bone Presenting Ewing Syndrome with Discussion of "Ewing's Sarcoma," Am. J. Path. **16**:317-332 (May) 1940.

360. King, B. B.: Solitary Plasma Cell Myeloma of Bone as Initial Stage of Multiple Myeloma, J. A. M. A. **115**:36-38 (July 6) 1940.

361. Gordon, H., and Schneider, B.: Plasma-Cell Myeloma in Child: Report of Case, Internat. Clin. **4**:173-181 (Dec.) 1940.

362. Plasma Cell Myeloma of Eleventh Thoracic Vertebra, with Intraspinal Epidural Extension, Cabot Case 26072, New England J. Med. **222**:274-276 (Feb. 15) 1940.

363. Lymphoblastic Lymphoma, Cabot Case 26221, New England J. Med. **222**: 927-929 (May 30) 1940.

the liver, there was evidence of hemopoiesis, compensatory for the extensive destruction of the marrow.

Hodgkin's Disease.—A case of Albers-Schönberg disease (marble bones) associated with Hodgkin's disease is described by Herscher and Stein.[364] They describe the association of Albers-Schönberg disease with fluorine intoxication and believe that in fluorine intoxication the excessive calcification frequently extends into adjacent structures of soft tissues, whereas in Albers-Schönberg disease this does not happen. Well defined differences are shown also in the histologic study. The causative factors in this case are not known, but the parents and the grandparents of the patient show a high incidence of Albers-Schönberg disease, and there is frequent occurrence in more than one member of the family. This suggests a hereditary defect of germ plasm which results in a disturbance of the whole hemopoietic system. Excessive osteoblastic activities involved most or all of the skeleton with association of fibrosis and enlargement of the liver, spleen and lymph nodes. Hemopoiesis is generally depressed.

Chordoma.—The problem of chordoma is reviewed in three papers. This tumor must be considered in a study of bone tumors because of the destruction of bone caused by its growth. The literature contains more than 150 cases. The chordoma arises from remnants of the embryonic notochord. The sacrococcygeal area is the most common site; one half of the tumors reported arise in this region. One third are in the suboccipital region. Roentgenologically the tumor is clearly outlined, with a midline area of bone destruction. It is very vascular and rather soft and translucent. The symptoms and signs arise from local pressure. The Mixters[365] report 3 cases and describe the surgical management used in them. Bowers[366] and Richards and King[367] report single cases and outline their surgical technic. Local recurrence is the rule, and the prognosis is not satisfactory.

Synovioma.—Lewis[368] presents 4 cases of synovioma in which there were unusual and similar roentgenographic findings. The diagnosis was synovioma or synovial sarcoma. In 2 of the cases there was clinical evidence that the tumor was malignant. In the other 2, although the growth was regarded as malignant or potentially malignant from the

364. Herscher, H., and Stein, J. J.: Osteopetrosis Associated with Hodgkin's Disease: Review of Literature and Report of Case, Am. J. Roentgenol. **43**:74-80 (Jan.) 1940.

365. Mixter, C. G., and Mixter, W. J.: Surgical Management of Sacrococcygeal and Vertebral Chordoma, Arch. Surg. **41**:408-421 (Aug.) 1940.

366. Bowers, W. F.: Sacrococcygeal Chordoma: Case Report, Nebraska M. J. **25**:341-342 (Sept.) 1940.

367. Richards, V., and King, D.: Chordoma, Surgery **8**:409-423 (Sept.) 1940.

368. Lewis, R. W.: Roentgen Recognition of Synovioma, Am. J. Roentgenol. **44**:170-174 (Aug.) 1940.

pathologic viewpoint, it had not shown recurrence or metastasis thirteen and seven months after operation, respectively.

The author summarizes his article as follows:

1. Four cases are described and illustrated in which distinctive and essentially identical roentgenograms were found to indicate malignant, or potentially malignant, synoviomas or synovial sarcomas.

2. This distinctive roentgen finding seems to occur in about 25 per cent of synoviomas.

3. Thus far, no other pathological condition giving similar roentgen findings has been encountered.

4. Whenever roentgenograms similar to those described are encountered, a provisional diagnosis of synovial sarcoma is justified, and the probability of malignancy should be borne in mind.

Black [369] reports a case of interdigital tumor of the foot of two years' duration. He states that although the great majority of synovial tumors so far reported have proved to be malignant a relatively benign type of bursal synovioma is believed to exist, as illustrated in this case and one which he previously reported. It is possible that the tumors might ultimately have become malignant if they had not been removed. Both, however, grew slowly and remained encapsulated for long periods (two and three years, respectively) prior to operation.

Stack [370] reports a case of synovial granuloma, a pediculate tumor of the knee with recurrent spontaneous hemarthrosis. "Microscopically the mass was found to be granulomatous in nature. Numerous inflammatory cells, fibroblasts and capillary blood vessels of various sizes were the essential features of the picture."

Xanthoma.—In a clinical and pathologic study of xanthoma of tendon sheaths and synovial membranes, Galloway, Broders and Ghormley [371] review 70 cases and conclude that

Xanthoma of the tendon sheaths and synovial membranes is a benign lesion associated primarily with an alteration in the lipoid metabolism secondarily set off by trauma, infection, or both. It is classified under the heading of the primary essential xanthomatoses.

Hemangioma.—The literature on vertebral hemangioma with neurologic symptoms is reviewed by Kelly.[372] He summarizes his findings as follows:

---

369. Black, W. C.: Synovioma (Synovialoma) of Foot: Case, Am. J. Cancer **39**:199-206 (June) 1940.

370. Stack, J. K.: Spontaneous Hemarthrosis Due to Synovial Granuloma, J. Bone & Joint Surg. **22**:735-737 (July) 1940.

371. Galloway, J. D. B.; Broders, A. C., and Ghormley, R. K.: Xanthoma of Tendon Sheaths and Synovial Membranes: Clinical and Pathologic Study, Arch. Surg. **40**:485-538 (March) 1940.

372. Kelly, L. C.: Vertebral Hemangioma with Neurologic Symptoms, New York State J. Med. **40**:1607-1612 (Nov. 1) 1940.

1. Primary hemangioma of the vertebra is a comparatively common condition but rarely gives rise to symptoms.

2. Symptoms, when present, may be divided into two groups: (*a*) compression of the spinal cord; and (*b*) pain in the back, with or without radiation.

3. Diagnosis can safely be made by the characteristic coarse-meshed appearance of the body of the vertebra produced by the vertical striations alternating with large areas of rarefaction in the bone.

4. Surgery should be attempted at once in all cases with advanced neurologic symptoms who are good operative risks, whereas radiation should be tried in those patients in whom pain is the only symptom or who are not in a position to undergo a major surgical procedure.

[ED. NOTE: In the opinion of other observers, roentgen therapy is the treatment of choice.]

Neurilemmoma.—DeSanto and Burgess [373] report 2 cases of neurilemmoma in bone. They state that neurilemmoma is a specific form of nerve sheath tumor which may occasionally occur as a primary tumor of bone and that the probable origin of the growth in the 2 cases cited and in the 2 previously reported in the literature is the nerve sheaths in the cortex or maybe the periosteum. Neurilemmoma may invade and excavate bone by direct extension from a paraosseous focus. Involvement of bone by a neurogenic tumor does not of itself indicate a sarcomatous transformation of a benign tumor. The authors caution that neurilemmoma of bone is not to be confused with neurofibroma.

The treatment suggested is conservative and consists of thorough curettage with cautery or subperiosteal resection and bone grafting. The possibility of neurilemmoma should be considered in diagnosing cystic expansive rarefactions of the midshafts of long bones.

New Types of Bone Tumors.—In 1935, Jaffe [374] reported 5 cases of osteoidosteoma. He and Lichtenstein [375] now present a second publication on this tumor with special reference to cases in which a lesion in the cortex of the shaft of a bone is commonly misclassified as sclerosing and nonsuppurative osteomyelitis or abscess of the cortex. They report a total of 33 cases with clinical, roentgenologic and histologic discussions as evidence that this condition is a benign neoplasm. They describe the lesion as being always small and affecting a single bone; it may develop in the substantia spongiosa or the cortex, and it stands out from the surrounding bone as a sharply delimited nidus.

373. DeSanto, D. A., and Burgess, E.: Primary and Secondary Neurilemmoma of Bone, Surg., Gynec. & Obst. **71**:454-461 (Oct.) 1940.

374. Jaffe, H. L.: "Osteoid-Osteoma": Benign Osteoblastic Tumor Composed of Osteoid and Atypical Bone, Arch. Surg. **31**:709-728 (Nov.) 1935.

375. Jaffe, H. L., and Lichtenstein, L.: Osteoid-Osteoma: Further Experience with This Benign Tumor of Bone, with Special Reference to Cases Showing Lesion in Relation to Shaft Cortices and Commonly Misclassified as Instances of Sclerosing Non-Suppurative Osteomyelitis or Cortical Bone Abscess, J. Bone & Joint Surg. **22**:645-682 (July) 1940.

In interpreting the roentgenogram in a case of osteoidosteoma, they caution that this picture has two aspects: the manifestation of the osteoidosteoma proper and that of the reaction it has incited in the surrounding tissue. The osteoidosteoma proper is usually indicated by a relatively radiolucent or rarefied area, although if it has become substantially ossified it may appear as a relatively radiopaque nidus. One may have difficulty in distinguishing the shadow of the osteoidosteoma in the cortex of a long bone if the thickening of the cortex is considerable or if the lesion has become ossified, since this shadow may be dominated by that of the thickened cortex.

Lichtenstein and Jaffe [376] believe they have presented a new bone tumor and give to it the name "eosinophilic granuloma" because of the presence of many eosinophilic polymorphonuclears. They feel it may be a virus granuloma, that it is benign and that it is cured by wide excision. The tumor occurs in young persons, especially boys and young men, and mainly involves the calvarium, but it may occur in other bones such as the ribs and the femur. The onset is sudden, with pain, swelling and tenderness. Roentgen examination shows a localized lesion starting in the medullary cavity and expanding and eroding the cortex. The course is rather rapid. The tissue of the tumor is yellowish or brownish and its microscopic appearance is characterized by phagocytosed eosinophils. Giant cells are likewise present. There may be an eosinophilia of the blood, and a sternal biopsy may show many eosinophilic cells.

Malignant Tumors Associated with Bone Diseases.—New growths are frequently superimposed on previously existing lesions. Sarcoma is not infrequently observed as a late manifestation in Paget's disease. Wolfe and Black [377] report an interesting case of Paget's disease with a superimposed intracranial neoplasm. The autopsy showed a thickened and spongy calvarium and a large and misshaped skull due to the enlarged frontal, parietal and occipital bones. Attached to the basal dura on the left side and extending posteriorly from the superior petrous border to the posterior fossa, there was a partially calcified spherical tumor 5 by 4 by 3 cm. This tumor compressed the cerebellum. The tumor tissue was reported to resemble sarcoma and to be a neoplastic process arising in association with Paget's disease.

Jewell and Lofstrom [378] report a case of associated fragilitas ossium and osteogenic sarcoma. Although these 2 conditions occurred together, it is not felt that there was any direct relation between the 2. The

376. Lichtenstein, L., and Jaffe, H. L.: Eosinophilic Granuloma of Bone, with Report of Case, Am. J. Path. **16**:595-604 (Sept.) 1940.

377. Wolfe, A. M., and Black, W. C.: Paget's Disease: Report of Case with Intracranial Neoplasm, Rocky Mountain M. J. **37**:586-587 (Aug.) 1940.

378. Jewell, F. C., and Lofstrom, J. E.: Osteogenic Sarcoma Occurring in Fragilitas Ossium: Case Report, Radiology **34**:741-743 (June) 1940.

familial history of the fragilitas ossium has been preserved by means of oral tradition for two to three hundred years.

Herzmark [379] reports a case history of a 52 year old man with periosteal fibrosarcoma superimposed on or associated with a Pellegrini-Stieda disease. Local resection and heavy roentgen irradiation was the treatment used, and at the end of seven years there was no evidence of recurrence.

Stewart, Obermayer and Woolhandler [380] present a case of carcinomatous degeneration of the epithelial lining of a chronic osteomyelitic cavity, with cutaneous metastatic lesions of squamous cell carcinoma. The earliest description of this type of lesion was probably given by Hawkins in 1835, as a case of a warty tumor in a cicatrix.

Metastatic Tumors in Bone.—The literature on tumors metastasizing to bone has come chiefly from roentgenologists. However, Batson [381] has performed a series of experiments to determine the function of the vertebral veins and their role in the spread of metastases. After a series of injections of the deep dorsal veins of the penis of adult cadavers and live monkeys and of the venules of the breast of the cadaver of a woman, he concludes that the metastasis of many tumors is not explained by the accepted theories. Vertebral veins, with their rich, valveless ramifications, offer a possible solution. Injection of the deep dorsal veins of the penis gives a pattern simulating the typical spread of carcinoma from the prostate gland. Injection of the venules of the breast duplicates the pattern of the spread of aberrant cancer of the breast into the spine, the ribs, the shoulder girdle and the skull. It is proposed that the veins of the brain, the skull, the viscera of the neck, the vertebral column (with the valveless connections in the pelvic and shoulder girdles) and the veins of the body wall be considered a separate overlapping system of veins, and it is suggested that the term "vertebral veins" be used to indicate this system, giving four venous systems: the caval, the pulmonary, the portal and the vertebral.

Turner and Jaffe [382] made a clinical and roentgenologic study of the involvement of the skeleton and lungs in metastatic neoplasms. Their work is summarized as follows:

---

379. Herzmark, M. H.: Periosteal Fibrosarcoma of Femur: Report of Case Without Recurrence Seven Years After Excision and Radiation Therapy, Bull. Hosp. Joint Dis. **1**:56-60 (July) 1940.

380. Stewart, C. D.; Obermayer, M. E., and Woolhandler, H.: Cutaneous Metastatic Carcinoma Originating from Osteomyelitic Cavities, Arch. Dermat. & Syph. **41**:545-550 (March) 1940.

381. Batson, O. V.: Function of Vertebral Veins and Their Role in Spread of Metastases, Ann. Surg. **112**:138-149 (July) 1940.

382. Turner, J. W., and Jaffe, H. L.: Metastatic Neoplasms: Clinical and Roentgenologic Study of Involvement of Skeleton and Lungs, Am. J. Roentgenol. **43**:479-492 (April) 1940.

1. Skeletal and pulmonary metastases have been considered in 1,803 patients in an attempt to further orient the present use of roentgenological investigation.

2. Bone metastases were distributed in essentially direct proportion to the amount of regional red bone marrow rather than the increasing proximity of the primary with the notable exception of those from the prostate.

3. Blood-borne osseous metastases in the absence of lung metastases were of sufficient frequency to emphasize the present clinical trend to search the skeleton for metastases even though the lungs may be negative. . . .

5. In several cases, positive demonstration of calcium in lung metastases coincided with the existence of osteogenic primary neoplasms.

Marks [383] studied 148 cases of cancer of the prostate gland. In 54 of these cases, there was evidence of bone metastases; in no case were bone metastases found in the skull and the extremities unless there were definite metastases in the pelvis and the spine.

In a study of metastasis to bone from carcinoma of the gastrointestinal tract, Stein [384] states that, although uncommon, it is not so rare as generally considered. The metastatic lesions are osteoclastic in type and most commonly involve the spine, the pelvis, the ribs, the femur and the skull.

Metastasis to bone from squamous cell epithelioma of the cervix uteri is unusual. Barany and Sala [385] report 2 cases, describing the metastatic lesion as single and large, in contrast to the lesion more commonly seen metastasizing from carcinoma of the breast.

Treatment.—During the past five years, there has been a perceptible increase of efficiency in the treatment of bone tumors. Resection of benign bone tumors and filling of the defect with massive bone grafts or bone chips has become a common procedure.

Burack [386] reports an ossifying enchondroma of the head of the humerus treated by resection of the involved portion of the shaft and replacement of the proximal portion of the fibula by a bone graft.

The surgical treatment of giant cell tumors is well crystallized by Inclán [387] in his report of a series of 8 cases of giant cell tumors presenting clinical, roentgenologic and pathologically benign aspects. These

383. Marks, J. H.: Study of Bone Metastases from Carcinoma of Prostate, Am. J. Roentgenol. **44**:732-736 (Nov.) 1940.

384. Stein, J. J.: Metastasis to Bone from Carcinoma of Gastro-Intestinal Tract, Radiology **35**:486-488 (Oct.) 1940.

385. Barany, E., and Sala, A. M.: Squamous Cell Epithelioma of Cervix Uteri with Metastasis: Report of Two Cases, Am. J. Roentgenol. **44**:579-585 (Oct.) 1940.

386. Burack, P. I.: Ossifying Enchondroma of Head of Humerus, Bull. Hosp. Joint Dis. **1**:3-8 (March) 1940.

387. Inclán, A.: Surgical Treatment of Giant-Cell Tumors of Bone, J. Internat. Coll. Surgeons **3**:389-399 (Oct.) 1940.

should warrant treatment by curettage, curettage and bone grafting, or excision and bone grafting. He has used block or massive resection in cases of recurrent giant cell tumor with what he calls "local malignancy" and in cases in which the tumor was of the "aggressive type" with clinical and roentgenographic indications that it was malignant. The defect in the bone is filled in to preserve the form. Amputation is done only when the patient is first seen in a far advanced stage, when there has been infection after a previously unsuccessful curettage or when there are positive signs that the tumor is malignant.

After treating primary sarcoma of bone by irradiation, Brunschwig and Tschetter [388] have followed a series of 20 patients without detecting clinical evidence of metastatic lesion. All the patients were unable to undergo or refused operation. In all cases diagnosis was confirmed by biopsy, and only conservative surgical intervention and irradiation or irradiation alone was used. Of these 20 patients, 6 have survived for three years or more without clinical evidence of extension of the disease. The authors' conclusion is that "an extremely pessimistic attitude regarding the value of irradiation in benefiting cases of primary bone tumor is not justified."

Phemister [389] in discussing conservative treatment of bone tumors reports 6 carefully selected cases of malignant primary bone tumor without demonstrable metastases. The tumors were well localized. They were treated by local excision and roentgen irradiation. One patient died of pulmonary metastasis without local recurrence, and 5 showed no recurrence after periods ranging from seventeen months to fourteen years. He urges more conservative procedures in carefully selected cases.

Ferguson [390] has made a detailed statistical study of 400 cases of osteogenic sarcoma reported in the Registry of Bone Sarcoma of the American College of Surgeons. As a result of this study, he recommends the following treatment for osteogenic sarcoma: (1) avoidance of early amputation ("Early amputation is defined as amputation before the seventh calendar month after onset of symptoms."); (2) irradiation before delayed amputation; (3) irradiation, excision and implantation of a bone graft or bone chips before amputation, with amputation before the recurrence becomes evident; repetition of excision, rather than amputation, if recurrence becomes evident before amputation can be done.

---

388. Brunschwig, A., and Tschetter, D.: Experiences in Treatment of Primary Skeletal Sarcoma by Irradiation, Am. J. Roentgenol. **44**:83-89 (July) 1940.

389. Phemister, D. B.: Conservative Surgery in Treatment of Bone Tumors, Surg., Gynec. & Obst. **70**:355-364 (Feb., no. 2A) 1940.

390. Ferguson, A. B.: Treatment of Osteogenic Sarcoma, J. Bone & Joint Surg. **22**:916-922 (Oct.) 1940.

XII. CONDITIONS INVOLVING THE LOWER PART OF THE BACK

Causation.—In an unusually comprehensive discussion of the spine from the anatomic, embryologic and physiologic points of view, Carey [391] correlates pain in the lower part of the back with scoliosis. He presents as illustrations many photographs of a "dynamic muscle-bone balance model of the human spine." It is stated that with only thirteen pairs of spinal muscles there are more than sixty-seven million possible combinations of muscular unbalance capable of producing lateral curvature. [ED. NOTE: This is a good article in spite of the unbelievable figures.]

To learn the relation of anomalies in the lower part of the back to injury, Connell [392] studied a group of 6,391 zinc miners over a period of five years. Anteroposterior roentgenograms were taken of the lumbosacral area, and 12.85 per cent of these miners were found to have spina bifida occulta of the sacrum or of the fifth lumbar vertebra. During the five year period 199 received injuries to their backs; this figure includes only those who felt a sudden catching pain while doing ordinary work. Those with external trauma were not included. Of the 199 injured, 172 had been submitted to roentgen examination, and spina bifida occulta had been demonstrated in 10.13 per cent of these. Thus the incidence of anomalies in the lower part of the back was less in the injured group than in the series as a whole. It was also determined that 20.29 per cent of the patients with normal spines had prolonged periods of healing or became subjects of litigation, compared with 10.53 per cent of the patients with spina bifida occulta. The author concludes that "spina bifida occulta is not a predisposing cause of simple back strain, and that it does not effect a prolonged healing period in individuals who have received injury to the spine." [ED. NOTE: This information should be of great importance to the industrial surgeon from the medicolegal point of view.]

A report by Carmichael [393] asserts that the most common cause of sciatica is one or more of the following pathologic conditions of the anus: a small pile in the posterior quadrant, a slight posterior prolapse, a buried fissure, a posterior crypt or a posterior papilla. The nervous connection of the anal sympathetic and parasympathetic nerve supplies to the sciatic nerve is traced, and the radiation of sciatica is explained on a reflex basis. Four cases are presented which illustrate the almost immediate relief of the sciatic pain after treatment of the associated lesion or lesions of the anus. [ED. NOTE: Lesions of the anus should be checked. Some of the author's statements seem a little far fetched.]

---

391. Carey, E. J.: Low Back Pain: Symposium; Anatomic Aspect, Wisconsin M. J. **39**:427-446 (June) 1940.

392. Connell, M. A.: Relationship of Spina Bifida Occulta to Back Injury, J. Oklahoma M. A. **33**:9-11 (July) 1940.

393. Carmichael, E.: Common Cause of Sciatica, M. Rec. **152**:8-10 (July 3) 1940.

Smith [394] reports 13 cases in which no other explanation could be found for sciatica than the hyperglycemic response to the one hour–two dose dextrose tolerance test. The patients presented themselves for relief of the sciatic pain and gave no history suggestive of diabetes. In 7 patients the pain had been present for one month or less; in 6 it had been present for from several months to several years. One patient was not improved by a diet and treatment with vitamin B_1 (thiamine) and insulin, another patient was improved but not relieved, and the remaining 11 patients were relieved of their pain. The diet consisted of 120 Gm. of carbohydrate, 80 Gm. of fat and 80 Gm. of protein. Ten units of insulin each day was used (except in 3 cases in which only the diet and the vitamin B_1 were used). The amount of the dose of vitamin B_1 is not stated. It has been shown that an increase in caloric intake requires an increase in vitamin B_1 intake, and the author offers a tentative explanation for neuritis associated with hyperglycemia as follows: Unmetabolized carbohydrate may enter into some combination with vitamin B_1 and withdraw it from the tissue or may exert some inhibiting influence on it. [ED. NOTE: This possible explanation of sciatic pain merits consideration. The information is from a reliable source.]

Disability from disease in the lower part of the back is becoming one of the most frequent grounds for claiming compensation in industry. Johnstone [395] reports a series of 3,018 cases of pain in the lower part of the back; many ages, races and social levels and many types of industry are represented. The study was made from April 1936 to February 1939. The contrast of the rejections on the grounds of the condition not being of occupational origin in 1936 (40 per cent) to those in 1939 (71 per cent) is understood when it is noted that in 1937 a policy of unlimited laboratory investigation was adopted. In addition, complete histories were obtained and physical examinations made. This policy of complete study resulted in finding (in over 70 per cent) pathologic conditions which when considered with a negligible history of injury formed a basis of rejection. The author states, "From the internists' viewpoint the so-called 'industrial back' is not primarily an orthopedic problem. It is one for differential diagnosis." [ED. NOTE: This is another good article for the industrial surgeon.]

Diagnosis.—That sciatica is of a reflex nature in a considerable number of cases is brought out by Steindler.[396] He states that recognition of this fact is essential for rational diagnosis and treatment of the underlying condition. Most strains in the lower part of the back result

394. Smith, C. T.: Sciatic Pain and Hyperglycemic Response to Glucose Tolerance Test, North Carolina M. J. **1**:315-317 (June) 1940.

395. Johnstone, R. T.: Industrial Back from Internist's Viewpoint, Am. J. Surg. **48**:544-547 (June) 1940.

396. Steindler, A.: Interpretation of Sciatic Radiation and Syndrome of Low Back Pain, J. Bone & Joint Surg. **22**:28-34 (Jan.) 1940.

from serious injuries to soft tissues. The author mentions six patterns of pressure or "trigger points" which indicate typical syndromes. These are as follows:

1. The sacrospinalis syndrome, producing a pressure point at the posterior superior or inferior iliac spine.

2. The lumbosacral syndrome, with a pressure point at the lumbosacral junction.

3. The gluteal syndrome, producing a pressure point at the gluteus maximus insertion.

4. The transversosacral syndrome, with a pressure point at the transversosacral articulation in cases of sacralization of the fifth lumbar vertebra.

5. The tensor fasciae latae syndrome, with the tender point at the lateral border of the fascia and iliotibial band and a positive Ober sign.

6. The myofascial syndrome, with vague tenderness along the sacrospinalis muscle and its fascial sheath.

Irritation of these trigger points aggravates radiation of the sciatica; injection of procaine hydrochloride eliminates such radiation.

[Ed. Note: This article should be studied. The real value of the author's "trigger points" will be determined by the report of experiences in other clinics.]

When there is pain in the lower part of the back for which no local cause can be demonstrated, the genitourinary system should be thoroughly investigated. Culver [397] discusses this subject. The tendency of low lying kidneys to produce pain is made especially evident when it is observed that they have a high incidence of deficient emptying power, characterized clinically by varying degrees of hydronephrosis. The pain is most often localized in front, but it may be present in the back alone, or there may be a combination of the two. Renal calculi, neoplasms and infections and bladder lesions present varied clinical pictures of pain in the lower part of the back or in the pelvis. Pain in the back from diseases of the prostate gland and the seminal vesicles may be caused (1) by a metastasis of the infection or the neoplasm to the spine, (2) by blood-borne toxins arising from infections in these structures or (3) by reflex nervous impulses arising from pressure or adhesions within the structures. Pain referred from the prostate gland and the seminal vesicles may occur over one or both sacroiliac joints, in the low dorsal or high dorsal regions of the spine. The pain is variously described as an ache, a dull pain, a soreness, a stiffness, a burning or a bearing down pain. Pain originating in the seminal vesicles is aggravated by pressure on that structure. Other implicated urologic conditions are chronic urethral conditions in women, metastasis from testicular neoplasms and varicocele. [Ed. Note: This is an excellent review.]

397. Culver, H.: Low Back Pain: Symposium; Urologic Aspect, Wisconsin M. J. **39**:450-456 (June) 1940.

Treatment.—In an article on the manipulative treatment of backache Jostes [398] stresses that it is contraindicated in all definitely pathologic conditions of the lower part of the back and should not be employed until these have been ruled out. Definite manipulations are carried out with the patient on the floor without anesthesia. Preliminary massage of the gluteal muscles and of the lumbar area relaxes spasm. Nine well planned maneuvers are described and illustrated, and a strict postoperative regimen of rest, exercise, heat and support is established. [ED. NOTE: This work of Jostes confirms a great many ideas of the late W. S. Baer.[399] Orthopedic surgeons give too little attention to manipulation. The author is to be congratulated on his work.]

By far the most common cause of backache is chronic postural strain, and for this condition physical therapy is of cardinal importance. Krusen [400] outlines the treatment as follows:

(1) Rest in bed with a fracture board on the springs and a firm hair mattress.

(2) Traction of 4 to 8 pounds (1.8 to 3.6 kg.) on each leg [which hyperextends the spinal column].

(3) A padded sling under the lumbar region of the spinal column. . . .

(4) Daily local applications of radiant heat and deep sedative massage, usually alternating with diathermy and massage.

(5) Occasional epidural injections if there is sciatic pain and if relief of pain is not obtained by traction.

(6) Finally, manipulation through an extended normal range under general pentothal sodium anaesthesia if previous treatment has failed to elicit a favourable response.

The author states that he has rarely noted more than temporary relief after manipulation but that this form of treatment possibly merits further consideration. [ED. NOTE: This is an excellent article on conservative therapy.]

Hoffman [401] has examined a large number of women complaining of chronic pain in the lower part of the back and has found in a great number a hard nodule situated posteriorly over one or both sacroiliac joints. When pressure is applied over the nodule, the pain is reproduced. One case is reported in which complete relief was obtained after excision of the one nodule found. Pathologic examination of the tissue showed nerve tissue, but the exact type was not determined.

---

398. Jostes, F. A.: Backache: Manipulative Treatment Without Anaesthesia, Mississippi Valley M. J. **62**:114-118 (July) 1940.

399. Baer, W. S.: Sacro-Iliac Strain, Bull. Johns Hopkins Hosp. **28**:159 (May) 1917.

400. Krusen, F. H.: Backache: Relation of Physical Therapy to Its Management, Canad. M. A. J. **42**:534-541 (June) 1940.

401. Hoffman, J. M.: Low Back Pain, J. Florida M. A. **27**:30-31 (July) 1940.

Rupture of Intervertebral Disks.—(*a*) Clinical Findings: A study of 100 cases is reported by Macey.[402] In 23 of these there was a history of adequate injury. In 9, the patient was not aware of injury but complained of sciatic pain coming on while standing with the spine in flexion. In 68 cases there was no association with injury. Of the 23 cases in which there was a history of injury, both backache and sciatica, usually continuous, were present in 9. In 2 there was continuous sciatic pain alone, and in 12 there was a history of backache with late onset of sciatica of many years' duration. Of the 68 cases in which there was no associated injury, persistent backache and sciatica were present in 13. In 13 there was a long history of backache and recurrent sciatic pain and in 34 a history of backache and later of persistent sciatic pain alone for many years. A detailed account of the physical observations is given in this report.

Keegan and Finlayson[403] report the clinical observations on 40 patients operated on by laminectomy. Seventy per cent of the patients complained of strain of the back. In 50 per cent the ankle jerk reflex was reduced, and in 55 per cent sensation in the affected leg was diminished. Motor power was reduced in 27.5 per cent, and control of the sphincters was affected in 7.5 per cent. In only 10 per cent of the patients was a block of the flow of spinal fluid demonstrated.

Thirty-five cases in which herniated intervertebral disks were found at operation are reported by Toumey.[404] The average duration of symptoms from the time of the first attack to the time of operation was five years. Five of the patients had bilateral and 30 unilateral sciatic pain. Paresthesias were present in 75 per cent, unilateral weakness of the leg in 69 per cent, and pain on coughing or sneezing in 52 per cent. Ninety per cent of the patients showed Lasègue's sign.

Williams[405] states that changes within the lumbosacral and less frequently in other lumbar intervertebral disks are undoubtedly the cause of symptoms in more than 90 per cent of patients having symptoms of pain in the lower part of the back and sciatica. Acute rupture of a disk usually occurs between the ages of 10 and 25 years and is the result of a definite compressive injury. Chronic destruction of a disk results from uneven distribution of weight at the lumbosacral junction. Increased lordosis, a lateral tilt, fragmentation of the facets and overriding the facets are mentioned as the causative factors. It is the author's opinion that in more than 95 per cent of the cases pain in the lower part

402. Macey, H. B.: Clinical Aspects of Protruded Intervertebral Disk, Arch. Surg. **40**:433-443 (March) 1940.

403. Keegan, J. J., and Finlayson, A. I.: Low Back and Sciatic Pain Caused by Intervertebral Disk Herniation, Nebraska M. J. **25**:179-184 (May) 1940.

404. Toumey, J. W.: Intervertebral Disk Protrusion, Lahey Clin. Bull. **1**:11-16 (Jan.) 1940.

405. Williams, P. C.: Low Back Pain, South. M. J. **33**:788-797 (Aug.) 1940.

of the back is due to mechanical alterations which have resulted in constriction of the foramens and an impingement on the nerve root rather than to prolapse of the disk itself. [ED. NOTE: Many will undoubtedly agree with the author's statements which are the result of many years of experience.]

(*b*) Diagnosis: Spurling and Grantham [406] present the differentiating points by which the interspace in which the rupture of a disk has occurred may be determined. When there is a rupture of the disk in the third lumbar interspace, one finds tenderness to deep pressure over the third lumbar spine or lamina; compression of the jugular veins produces paresthesias in the fourth and the fifth lumbar dermatomes. There are reduction or absence of the knee jerk reflex and hypesthesia and paresthesias in the fourth and fifth lumbar dermatomes. With rupture of the disk in the fourth lumbar interspace there are tenderness over the fourth spinous process and paresthesias in the fifth lumbar and first sacral dermatomes; knee and ankle jerk reflexes are not affected. With rupture of the disk in the fifth lumbar interspace there are tenderness in the region of the fifth lumbar vertebra, paresthesias in the first and second sacral dermatomes and diminution or absence of the ankle jerk reflex.

According to Hampton,[407] a diagnosis of herniation of an intervertebral disk was established in 133 cases with an accuracy of 93 per cent by roentgen examination after injection of iodized oil into the spinal subarachnoid spaces. Nevertheless, he advises that air myelography be used first, even though its accuracy is probably not over 50 per cent. It is reliable when the findings are unequivocally positive, and its use may obviate in about half the patients the injection of iodized oil, which is a foreign body and in some instances has produced symptoms. He warns against following air myelography with an injection of iodized oil before the air has been absorbed and a normal flow of spinal fluid reestablished. He describes a technic of roentgen examination in detail.

Wartenberg [408] believes that since myelography is neither absolutely harmless nor absolutely decisive it should not be a routine neurologic procedure. He would reserve it as a last resort in the comparatively rare cases in which the "whether" or the "where" of surgical intervention cannot be decided by clinical neurologic methods.

---

406. Spurling, R. G., and Grantham, E.: Low Back and Sciatic Pain Caused by Rupture of Intervertebral Disc With or Without Herniation of Nucleus Pulposus, Internat. Clin. **4**:251-266 (Dec.) 1940.

407. Hampton, A. O.: Iodized Oil Myelography: Use in Diagnosis of Rupture of Intervertebral Disk into Spinal Canal, Arch. Surg. **40**:444-453 (March) 1940.

408. Wartenberg, R.: Remarks on Myelography, J. Nerv. & Ment. Dis. **91**:47-52 (Jan.) 1940.

[ED. NOTE: The ideal substance for use in myelography has not yet been found.]

(*c*) End Results: Of the 40 patients operated on by laminectomy in Keegan and Finlayson's [403] series, 60 per cent had definitely herniated disks, and 25 per cent had a thickened ligamentum flavum with a protruded disk. Their end results were graded according to the degree of recovery. In 57.5 per cent of the cases there was 90 to 100 per cent recovery; in 17.5 per cent there was 80 to 90 per cent recovery, and in 10 per cent there was a 50 per cent recovery. Failure to have any recovery occurred in 15 per cent. Toumey [404] classified 31 of his patients on whom operation had been performed according to end results after an average period of eight months. Twenty were rated as having excellent results; 3, good; and 8, poor. Williams [405] reported relief of sciatica without operation in 90 per cent of his cases. His conservative management consisted in correcting the lordosis and relieving the tight muscles and fasciae of the anterior and lateral aspects of the thigh. Facetectomy and grafting were done on 32 patients in whom the condition was resistant, and relief of segmental symptoms was obtained in all but 1, who died after operation. Mixter and Barr [409] report 123 consecutive cases in which operation was performed. One patient died after operation. They followed 77 of the patients one year or more and reported the results as good in 80 per cent, fair in 10 per cent and poor in 10 per cent. [ED. NOTE: All these reports of end results are establishing this as an accepted disease entity.]

Spondylolisthesis.—Hitchcock [410] presents 3 cases of definite progressive anterior displacement of the last lumbar vertebra. In none of the cases was trauma a significant feature. In each case there was increasing thinning of the disk. Interruption of the continuity of the neural arch occurs in 5 to 6 per cent of persons, and this is the fundamental lesion which precedes and causes spondylolisthesis. The author reviews the evidence that a defect in the narrow isthmic or interarticular portion of the neural bow at the junction of the pedicle and the lamina is of congenital origin and the result of separate centers of ossification; he concludes that it is insufficient to prove this popular theory. He produced fractures through this isthmus by flexing fetal spines but was unable to do so by extending them and suggests that trauma during delivery or shortly afterward may be the cause of this defect. [ED. NOTE: This article should be read in full; it is one of the best on spondylolisthesis written in many years.]

---

409. Mixter, W. J., and Barr, J. S.: Protrusion of Lower Lumbar Intervertebral Disks, New England J. Med. **223**:523-529 (Oct. 3) 1940.

410. Hitchcock, H. H.: Spondylolisthesis: Observations on Its Development, Progression, and Genesis, J. Bone & Joint Surg. **22**:1-16 (Jan.) 1940.

XIII. CONDITIONS INVOLVING THE SPINE AND THORAX, EXCLUSIVE OF THOSE IN THE LOWER PART OF THE BACK

Scoliosis.—(*a*) Causes: Bisgard and Musselman [411] believe "that inequality of growth on the 2 sides of the vertebral bodies plays a major rôle in the production and progression of idiopathic scoliosis. If not the primary etiological factor, as it may well be, it is an important contributing factor." They present experimental data to show that scoliosis can be produced in kid goats by arresting the growth of the epiphyses of the vertebral bodies on one side. In their discussion the question is raised, "If unilateral growth retardation is the sole factor responsible for idiopathic scoliosis, what causes this unilateral retardation of growth?" and they suggest that "among the theoretically possible causes are epiphysitis or epiphyseodystrophy and congenital abnormality of the cartilage." [ED. NOTE: While the growth or unequal growth of the vertebral epiphyses may well be a factor in some cases of scoliosis, it seems unlikely that this is the primary cause of so-called idiopathic scoliosis. It is frequently pointed out that idiopathic scoliosis increases during the period of growth, but it is seldom mentioned (if it is recognized) that in growing children with idiopathic scoliosis the curve does not always increase when the spine grows longer. There are other objections to the theory that unilateral retardation of growth is the cause of idiopathic scoliosis, and it is questionable that epiphysitis may be a cause of this unilateral retardation of vertebral growth, especially when it is remembered that in most children with this disease of the vertebrae dorsal round back tends to develop, and lateral curvature, if present at all, is always the lesser problem.]

The experimental production of scoliosis by Haas [412] and Bisgard and Musselman is of special interest. The former worked with dogs and the latter with kid goats. They have shown that growth in the length of vertebrae is derived from the proximal and distal epiphysial growth cartilages. They were able to produce lateral curvatures experimentally by injuring the epiphysial plate. Haas was able to prevent this deformity by vertebral fusion after the injury. He points out that there is a definite tendency toward lordosis after fusion of the spine in growing animals, that lordosis may correct existing kyphosis and that in cases of tuberculosis of the spine there may be a lessening of the deformity after fusion. [ED. NOTE: It should be added that this result may be due partly to the removal of the prominent spinous processes. If

411. Bisgard, J. D., and Musselman, M. M.: Scoliosis: Its Experimental Production and Growth Correction; Growth and Fusion of Vertebral Bodies, Surg., Gynec. & Obst. **70**:1029-1036 (June) 1940.

412. Haas, S. L.: The Prevention of Deformity of the Spine by Vertebral Fusion, J. Bone & Joint Surg. **22**:157-160 (Jan.) 1940; Influence of Fusion of the Spine on the Growth of the Vertebrae, Arch. Surg. **41**:607-624 (Sept.) 1940.

there is any real growth in the anterior vertebral area over the fused area, it may well be only in the part fused above or below the involved vertebrae, for it is well known that the epiphyses are frequently so involved that no further growth of the vertebral body is possible. Frequently, the whole development of the patient is retarded, and the growth of the entire spinal column may be relatively slight.] Haas states that this corrective influence (tendency to lordosis) should be borne in mind in the treatment of vertebral epiphysitis (kyphosis dorsalis juvenilis). [ED. NOTE: This seems to be an important suggestion, since it is well known that operation for fusion of the spine is usually performed too late to obtain the desirable cosmetic correction.] Haas states,

> The effect of fusion of the spine on a very young growing person needs careful study. It is possible that in some cases it may aggravate rather than decrease the deformity. Therefore, it is important to select the proper region of the spine, the correct age for fusion and the proper number of vertebrae to fuse.

[ED. NOTE: It might be added that the position of the spine when fusion is done is also important. In some cases of paralytic scoliosis in which the curve is increasing in spite of all conservative treatment, it might be possible by fusing the spine in a position of slight flexion to prevent or limit the development of objectionable lordosis during later years of growth, especially if the patient is young at the time of fusion.]

Haas states: "With the Albee type of operation if the markers are attached to the graft there is no separation of the markers, because there is no interstitial growth in a graft. The grafted region may be increased to some extent if bone is added to either end by a proliferation of osseous tissue adjoining the grafted area." Bisgard and Musselman, however, conclude that "under the influence of a distracting force, bone, that is, grafted bone is capable of intrinsic growth in length." [ED. NOTE: The experimental observations of Haas that growth of the fused area of the spine is definitely retarded and that deformity (lordosis) may develop as the child continues to grow is important. It has been pointed out by other workers for years that the spine continues to grow after fusion; some even believe that its growth is retarded relatively little if at all. Probably the rest of the spine continues to grow, but the fused area grows little, if at all, in most cases. The correction of the curvature usually gives the patient a definite increase in height.]

(*b*) Treatment: Bisgard and Musselman state:

> From the . . . experimental evidence that growth on one side of vertebrae can be arrested by removal of portions of the epiphyseal growth cartilages on that side, the possibility of accomplishing correction of curvatures of idiopathic scoliosis in suitable cases by this means suggests itself. The type of case which would seem suitable for this proposed form of treatment would be a child who has a moderate curvature and several years in which to grow. With growth

arrested on the side of convexity in several vertebrae at or near the apex of the curvature, any increase in length on the side of concavity should bring about some correction of the cuvature.

They believe that with resection of segments of two ribs it should be possible to expose six or more of the vertebral bodies in a patient with scoliosis. [ED. NOTE: Besides the technical difficulties of the treatment proposed one might mention that it is questionable whether as much correction of curvature could be obtained in this way as by the method now used, that is, correction in a turnbuckle jacket followed by fusion of the spine. It is likely that only mild curvatures could be corrected sufficiently by growth of the concave side, and it is doubtful whether any operation at all is indicated for these. For larger curvatures correction followed by fusion would probably give better results.]

Anatomic Variations of the Spine and Thorax.—Most congenital malformations of the spine have been described in the literature. However, Mayoral [413] describes a congenital malformation of the transverse process of the first dorsal vertebra which apparently has not been previously reported. He presents 1 case in which the anomaly had been considered an ununited fracture. On reviewing 5,632 roentgenograms he found 4 additional cases in which there was nonunion of the transverse process of the first dorsal vertebra; in 2 there was bilateral nonunion and in 2 there was nonunion of the left process. Because of possible medicolegal or compensational aspects it may be important to recognize this apparently rare variation.

Schüller [414] discusses "basilar impression" or "basilar invagination," terms generally used to designate different types of deformities involving the posterior cranial fossa and the upper cervical vertebrae. He describes three types due to (1) an abnormal structure of the skeleton, as in decalcification of the bone in rickets or Paget's osteitis deformans, (2) long-standing increased intracranial pressure causing atrophy of the cranial capsule (e. g. hydrocephaly) and (3) congenital malformation in the atlanto-occipital region (assimilation of the atlas). The anatomic findings in the different types are variable. As a rule the weighted parts of the occiput forming the foramen magnum are pushed up toward the cranial cavity (whence the term "basilar impression"). Clinically there is the characteristically short neck, often combined with a caput obstipum (wryneck). Movements of the head are usually free, and there is no fixation of the neck as in Pott's disease. There may be no untoward symptoms during the life of some patients, but others may

413. Mayoral, A.: Congenital Malformation of the Transverse Processes of the First Dorsal Vertebra, Radiology **35**:82-83 (July) 1940.

414. Schüller, A.: Diagnosis of "Basilar Impression," Radiology **34**:214-216 (Feb.) 1940.

show severe symptoms owing to compression of the spinal cord. The symptoms are usually slowly progressive with occasional acute exacerbations. The most common erroneous diagnosis in cases of basilar impression are: occipital neuralgia, syringomyelia, syringobulbia, the Klippel-Feil syndrome and cerebellar tumor. Decompressions are occasionally done with the mistaken idea that cerebellar tumor is present. The author points out that the characteristic deformities of the posterior cranial fossa and of the upper cervical vertebrae are well seen in lateral and anteroposterior roentgenograms, which help one to avoid an erroneous diagnosis and a dangerous and unnecessary operation.

Infectious Lesions of the Intervertebral Disks.—Ghormley, Bickel and Dickson [415] "emphasize the occurrence of a lesion of the spine involving principally the intervertebral disks with a more or less severe febrile onset, as a rule, denoting in all probability a primary or secondary infectious process as the underlying cause." They differentiate this condition from osteomyelitis of the spine and present a good differential diagnosis covering tuberculosis, osteomyelitis, typhoid spine, Brucella abortus infection, traumatic injury to the disk, congenital absence of the disk and fusion of the vertebrae. They feel that a preexisting infection is often, if not always, necessary and that the lesion itself is a metastatic infection incidental to dissemination of a preexisting infection through the blood stream. The clinical findings were pain, spasm of muscles, limitation of motion and tenderness, and some of the patients were severely ill with elevation of temperature and prostration. This condition must be especially differentiated from true osteomyelitis of the spine with the formation of an abscess requiring drainage and particularly from osteomyelitis of the vertebrae which may be complicated by neurologic manifestations and demand laminectomy and drainage of a localized abscess.

The syndrome is similar to osteomyelitis of the spine, but because of the minor involvement of the vertebrae and the apparently infrequent suppuration we feel that the condition should be regarded as a separate entity. This is probably the same condition as was seen in some cases of "typhoid spine" and as may be seen in the course of infections with *Brucella abortus*. The prognosis both as to life and prevention of disability is excellent in most cases. Treatment should be by conservative orthopedic measures, surgical procedures seldom being indicated.

Osteochondritis Vertebralis.—Fawcitt [416] reports a case in which osteochondritis vertebralis (Calvé) was associated with pathologic cystic

415. Ghormley, R. K.; Bickel, W. H., and Dickson, D. D.: A Study of Acute Infectious Lesions of the Intervertebral Disks, South M. J. **33**:347-353 (April) 1940.

416. Fawcitt, R.: Osteochondritis Vertebralis (Calvé) Associated with Pathological Changes in Other Bones, Brit. J. Radiol. **13**:172-178 (May) 1940.

changes in other bones, a condition which evidently has not been previously described and of which the exact significance is not yet known. He studied the case carefully, taking roentgenograms monthly and investigating the whole skeleton. He points out that the distribution of the cystic changes is noteworthy; they were seen in the head, neck and proximal portions of the shafts of the long bones in which they occurred (femur and humerus). There was no evidence of any bending of these bones, and cystic changes were not distributed throughout the shafts as in general osteitis fibrosa.

Tetanus and Deformities of the Spine.—Dietrich, Karshner and Stewart [417] discuss the problem of tetanus and lesions of the spine in children. They note that with the increase in the number of recoveries there has also been an increase in the number of patients showing vertebral deformities. They suggest the possibility of preventing at least some of these deformities by early and vigorous sedation. Examination of 9 of 13 patients who had had tetanus in childhood showed compression of thoracic vertebrae without a demonstrable fracture line. One vertebra was involved in 2 cases; two vertebrae in 1 case; three vertebrae in 2 cases; four vertebrae in 2 cases; five vertebrae in 1 case, and six vertebrae in 1 case. The fifth dorsal vertebra was involved in 8 cases; the sixth in 7 cases; the ninth in 2 cases; the eighth in 4 cases; the fourth in 2 cases, and the seventh in 6 cases. In the cases in which there was least involvement, the compression was limited to the anterior portion of the vertebral body. In the cases in which there was more severe involvement, the entire vertebral body was compressed from above downward. Most of the affected bodies were wedge shaped. In those cases in which involvement was most severe, the density of the compressed bodies was increased. The intervertebral spaces were unchanged. The upper and the lower borders were smooth and straight except in the bodies most severely affected, in which they were slightly concave in lateral projection. In some instances the compression reduced the height of the body to less than half of normal. The involvement centered about the fifth and sixth thoracic segments, extending as high as the fourth and as low as the ninth, thus differing in location from kyphosis dorsalis juvenilis, in which the changes are most severe in the eighth and ninth thoracic vertebrae and always limited to the lower half of the thoracic spine. The authors give a good differential diagnosis and disagree with the explanation of the mechanism of the deformity as described by Roberg [418] in 1937. They believe the dorsal portion of the

417. Dietrich, H. F.; Karshner, R. G., and Stewart, S. F.: Tetanus and Lesions of the Spine in Childhood, J. Bone & Joint Surg. **22**:43-54 (Jan.) 1940.

418. Roberg, O. T., Jr.: Spinal Deformity Following Tetanus and Its Relation to Juvenile Kyphosis, J. Bone & Joint Surg. **19**:603-629 (July) 1937.

spine is not flattened in the opisthotonic position but that all the normal spinal curves are increased, the muscles tending to approximate their ends and along an axial line approximating the occiput and the pelvis, with the greatest force exerted on the apical bodies of the thoracic vertebrae.

Epiphyses and Growth.—Nathan and Kuhns [419] report 75 cases in which epiphysitis of the spine was studied during the course of the disease. They describe the end results in 27. The diagnosis was confirmed roentgenologically in every case. The patients were 50 women and 25 men. The authors separate the condition into three stages: early, healing, healed. The healed stage is reached when the epiphyses are united and the deformities are fixed in varying degrees. The changes seen at this stage remain constant throughout life. In 60 cases there was involvement of the thoracic area; in 13, of both the thoracic and the lumbar area; in only 2, of the lumbar area. The authors believe that early treatment can prevent deformity, and they recommend exercises, rest and good hygiene; if this is unsuccessful, then a plaster jacket with the spine in as much extension as possible. [ED. NOTE: The problem of vertebral epiphysitis is still a difficult one, and many patients are seen too late to prevent deformity. The deformity is often severe and probably in many cases could be efficiently prevented only by early fusion of the involved vertebrae. It seems that most fusions are done too late to prevent the increasing deformity or to gain correction by the possible growth of the anterior elements of the vertebrae after the fusion has stopped the growth of the posterior elements.]

MacGowan [420] in a paper on the roentgen examination of normal spines and of kyphotic spines of adolescent persons describes the normal standards for the roentgenographic appearance of the spines of patients 8 to 19 years of age, a period of rapid growth which presents roentgenographic peculiarities, more manifest in the spinal than in any other osseous growth. He describes the appearance of the spinal column at birth, at 7 years of age, at 10 years (at this time the epiphysial rings appear), at 13 years and at 18 to 25 years. He traces the stages (as he sees them) and believes that the active stage lasts from one to two years and that it is self limiting. The final healed or arthritic stage is characterized by cuneiform ossification of the disk. [ED. NOTE: The adolescent kyphotic spine presents a difficult and important orthopedic problem. In many instances it is treated over a period of years, often long after any treatment is necessary. Most orthopedic surgeons do

419. Nathan, L., and Kuhns, J. G.: Epiphysitis of the Spine, J. Bone & Joint Surg. **22**:55-62 (Jan.) 1940.

420. MacGowan, T. J. B. A.: Radiologic Examination of Normal and Adolescent Kyphotic Spines, Glasgow M. J. **133**:206-209 (June) 1940.

not know just when to stop treatment. Many feel that the condition continues to increase up to the age of 19 or 20. The difficulty is in knowing the time and point beyond which no further treatment is necessary. There still are no definite indications as to which lesions are going to progress to serious kyphosis and deformity (for which fusion of the spine is probably the only adequate treatment) and as to which will get along well with little, if any, increase in deformity.]

Gonadal Dysfunction and Vertebral Growth.—Lindgren [421] reports a study of the vertebral column in connection with the treatment of eunuchoidism in men and women. By roentgen examination he noted several open epiphyses in patients 32 years of age and thinks that the irregular ossification of epiphysial plates in the vertebrae (indicative of inhibited development) is probably due to gonadal hypofunction. Although the inhibited ossification did not produce a noticeable increase in the size of the vertebrae he feels that the extended growth of the long bones in contrast to the lesser growth of the vertebral column is a result of the persistence of the epiphyses and that this explains the typical eunuchoid proportions of the body. [ED. NOTE: This paper brings up the interesting problem of the effect of the gonads on the growth of the vertebrae and other bones. There are indications that sex factors may be important in various conditions such as adolescent or idiopathic scoliosis and kyphosis.]

Senile Osteoporosis.—Black [422] reports 208 cases, in 80 per cent of which the patients were women. The average age was 62 and the youngest 45 years. In this series the earliest symptoms were weakness, fatigue and dull backache for an average period of three years. The patient then usually suffered some trauma or had a spontaneous sensation of cracking in the back, followed by severe acute pain and later intermittent acute attacks of pain. The lower dorsal and lumbar regions were most commonly affected. The author points out that senile osteoporosis must be differentiated from fracture, metastatic tumor and myeloma.

Zacho [423] reports only 3 cases but gives an excellent discussion of osteoporosis. After mentioning the characteristics and symptoms, he deals more fully with the cause of the disease. He believes that the cause of the primary form is nearly always a defect in diet (most

421. Lindgren, A. G. H.: Vertebral Column and Eunuchoidism, Fortschr. a. d. Geb. d. Röntgenstrahlen **60**:448-456 (Dec.) 1939; abstracted, J. A. M. A. **14**:1026 (March 16) 1940.

422. Black, J. R.: Senile Osteoporosis, Proc. Staff Meet., Mayo Clin. **15**:619-623 (Sept. 25) 1940.

423. Zacho, A.: Osteoporosis and Osteomalacia Columnae, Acta orthop. Scandinav. **11**:264-295, 1940.

frequently a deficiency of vitamin D). The secondary form may depend partly on disturbances in absorption (in diseases of the intestinal canal, the liver, the bile ducts and the pancreas), partly on disturbances in excretion (diseases of the kidney) and finally on disturbances of the internal secretions. In the form due to disturbances of absorption, defective absorption of vitamin D and possibly also of calcium salts is the most usual factor. Zacho discusses the similarity of senile osteoporosis, hunger osteomalacia and puerperal osteomalacia with involvement chiefly of the spine, the pelvis, the thorax and the shoulder girdle. He states that

> it is now generally agreed that puerperal osteomalacia and rickets are in reality different results of the same cause. . . . The difference in the locality of the diseases is due to the fact that parts of the skeleton that grow most rapidly are those most attacked. This explains why it is principally the skull that is most attacked in childhood (rickets) amongst older children preferably the long bones (late rickets), and, after increase in height has ceased, the pelvis, spine and thorax (osteomalacia).

He believes that the basic factor in all these cases is a deficiency of vitamin D in the diet, because the function of this vitamin consists in facilitating the absorption of calcium from the intestinal tract as well as in retaining the absorbed calcium in the bone.

Zacho believes that the prognosis for primary osteomalacia is good if the condition is treated early. The prognosis for the secondary form depends on the cause of the primary disease; if this is incurable, a constant addition of a surplus of vitamin D and calcium salts may be necessary to prevent recurrence of the bone disease.

[Ed. Note: It seems important to bring out the significance of vitamin D in relation to senile osteoporosis. Probably the pain, the disability and the deformity that are associated with this disease could be obviated for many patients if patients were given adequate prophylactic doses of vitamin D when they consult the physician for other reasons. The round back deformity of old age, which seems to be common, and the frequent lesions of the spine, such as compression fracture after relatively slight trauma, are probably related to vitamin D deficiency, either to the primary form due to a defect of diet or to the secondary form due to disturbance of absorption, excretion or internal secretion.]

Radicular Syndrome and Referred Pain.—As pointed out by Ussher,[424]

> The existence of radiation phenomena as the result of radiculitis, "intercostal neuritis," and parietal muscle spasm due to disturbances in the region of the

424. Ussher, N. T.: The Viscerospinal Syndrome: A New Concept of Visceromotor and Sensory Changes in Relation to Deranged Spinal Structures, Ann. Int. Med. **13**:2057-2090 (May) 1940.

spine, is now generally accepted by clinicians, more particularly by orthopedic surgeons and less universally by the internist. Two chief considerations have been stressed in this "radicular syndrome," viz.: (1) cutaneous hyperesthesia and tenderness in the distribution of the spinal segment involved, and (2) muscle spasm or atrophy of muscle groups in the somatic periphery related to this segment.

He adds a third, a visceral component, and discusses this "viscerospinal syndrome," as he describes "the physiological changes in the viscera produced by essentially the same factors as cause the parietal radiation phenomena." He delineates the pathways involved in "the possible anatomical and physiological connections between the autonomic fibers found in the skin, dorsal musculature and vertebral articulations on the one hand and autonomic fibers innervating the viscera on the other." He groups the different visceral components with the related segmental levels of the nervous system and stresses the importance of this syndrome in the differential diagnosis of visceral disease. He reports more than 400 instances of this syndrome, in at least 40 per cent of which there were multiple manifestations dependent on the various segmental levels involved. He discusses the many symptoms referred to the head, the neck, the chest, the heart, the lungs, the alimentary canal and the genito-urinary tract which may be due to stimulation of the skin, the dorsal muscles or vertebral articulations. He gives an explanation for the relief of many visceral symptoms, such as asthma and cardiac and gastrointestinal symptoms, which is said to be obtained by osteopathic treatments or physical therapy and stresses the importance of postural training and physical therapy in the relief of many patients with these visceral disorders.

Rich [425] discusses one phase of this so-called radicular syndrome or "viscerospinal syndrome" which he terms "spinal appendicitis." He points out that

it is now becoming more generally recognized that many pains in the body are not due to local or visceral diseases but are referred pains originating from strain, trauma or inflammation in or around the intervertebral foramina. Two regions of the spine are particularly susceptible to strain or injury. They are the dorsi-lumbar, the region of greatest mobility, and the lumbo-sacral, the region carrying the greatest weight. Both areas are situated at the junction of a primary fixed curve with a secondary mobile curve.

The author points out that while "it is generally agreed that sciatica originates in and is referred from the lumbo-sacral region . . . referred pain from the dorsi-lumbar region is not so generally recognized." He states that in older, more rigidly supported spines, the strain will be felt in the lumbosacral region since here there is greater

425. Rich, C. B.: Spinal Appendicitis, Canad. M. A. J. **43**:260-264 (Sept.) 1940.

weight, and lessened mobility of the spine as a whole would concentrate the forces of gravity at this point. In most cases, therefore, the patients are middle-aged persons. Rich then described the long lean type of adolescents (in whom appendicitis is common) with poor posture, subjected to unusual fatigue and back strain and frequently introverted, who complain of pain in the right side of the abdomen, which is often confused with pain due to appendicitis. He points out that the differenterial diagnosis in these cases in which pain is referred from the dorsolumbar area is aided by the observation that the pain is always relieved by rest, returning on active or passive movement, and that while tenderness and muscle spasm may be present the other signs and symptoms of appendicitis are absent. Huckell [426] observes that on "tightening the abdominal muscles, and on palpation, the pain is still present. In intraperitoneal lesions the pain is absent." Rich advises search for foci of infection, training on correct posture, use of supporting belts and avoidance of fatigue and any occupation or movement which involves strain.

Ussher stresses the importance of the skin, the dorsal muscles and the vertebral articulations, and Rich discusses the vertebral bodies with hypertrophic arthritis, the nucleus pulposus, the intervertebral ligaments, the ligamentum flavum, the apophysial joint affected by inflammation and swelling and especially the intervertebral foramens, as the sites of lesions producing referred pain; Goldthwait,[427] however, points out the importance of the rib joints as a source of referred pain. He states that the twenty-four costovertebral joints and the twenty costotransverse joints (never entirely at rest unless they become ankylosed) "may become irritated, strained or diseased, with the added possibility of irritation of the nerves adjacent to the joints and pain referred to the distribution of the special nerves." He points out that in the position in which the body is often held the chest sags and the head and shoulders are rounded forward so that the ribs hang below the normal low point of rib function (the neutral position is about 30 degrees downward from the horizontal). He likewise states that

> since there is no costotransverse articulation to limit the motion of the main joint, and since the rib is not supported in front by the costosternal cartilage, the floating ribs, two on each side, are able to sag and move about much more, naturally with much greater strain on the rib joint, and with much greater possibility of irritation of the nerve root and trunks. The posterior position that these ribs frequently assume must mean not only a marked backward position of the rib itself, with strain to the joint, but twist of the rib as well. The

426. Huckell, R. G., cited by Rich.[425]

427. Goldthwait, J. E.: The Rib Joints, New England J. Med. **223**:568-573 (Oct. 10) 1940.

referred pain that would come from irritation of the nerve roots adjacent to these ribs is referred to the sides of the abdomen from the pubic bone to the crest of the ilium. . . . Also, since there is a sympathetic ganglion connected with the nerve adjacent to the head of the rib, some of the circulatory disturbances undoubtedly find their explanation in irritation of this ganglion.

[ED. NOTE: These three articles are indicative of the increased interest in the problem of referred pain, especially that from lesions of the spine, and they bring out some important diagnostic points which are probably frequently overlooked. The recent more general use of superficial or deep injection of local anesthetics for various lesions related to the spine will probably add more light to the diagnostic and therapeutic difficulties in the problem of the lesions of the spine. The importance of poor posture as a cause of many symptoms other than backache and fatigue is now more generally appreciated.]

(To be concluded)